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MX SITING INVESTIGATION. AGGREGATE RESOURCES STUDY, TULE VALLEY--ETC(U)

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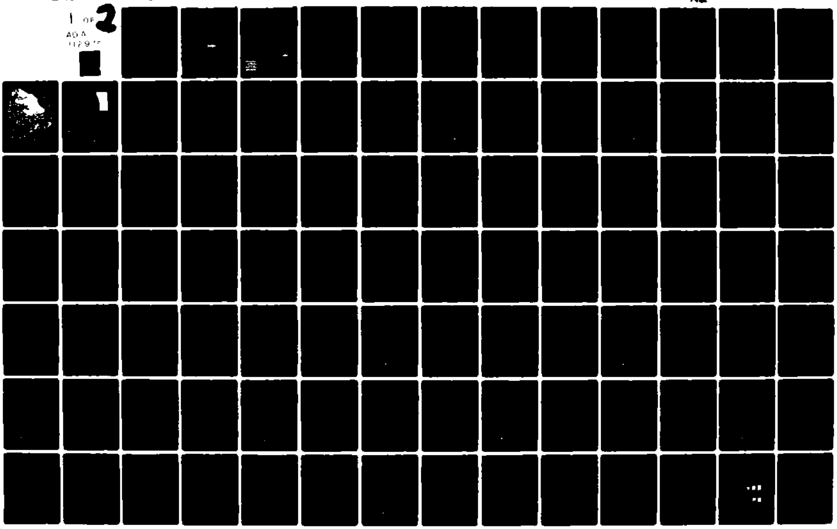


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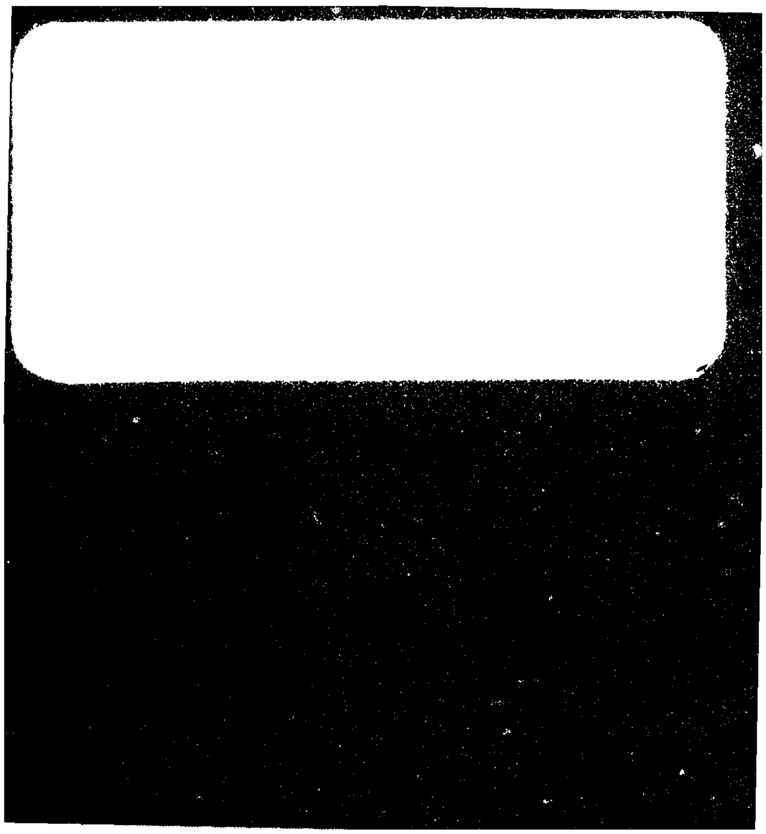

E-TR-37-h

AGGREGATE RESOURCES STUDY

TULE VALLEY

UTAH

Prepared for:

U.S. Department of the Air Force
Ballistic Missile Office (BMO)
Norton Air Force Base, California 92409

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3 July 1981

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This report presents results of the Valley-Specific Aggregate Resources Study (VSARS) for Tule Valley and surrounding areas in Utah. It is the eighth in a series of reports that contain aggregate information on the location and suitability of basin-fill and rock sources for concrete and road-base construction materials on a valley-specific basis. The findings presented are based on field reconnaissance and limited laboratory testing, existing data from the Utah State Department of Highways, and a previous regional aggregate investigation and Verification studies conducted by Ertec Western Inc.

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FOREWORD

This report was prepared for the Department of the Air Force, Ballistic Missile Office (BMO), in compliance with Contract No. F04704-80-C-0006, CDRL Item No. 004A2. It presents the results of Valley-Specific Aggregate Resources Studies within and adjacent to selected areas in Nevada that are under consideration for siting the MX system.

This volume contains the results of the aggregate resources study in Tule Valley. It is the eighth of several Valley-Specific Aggregate Resources investigations which will be prepared as separate volumes. Results of this report are presented as text, appendices, and two drawings.

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EXECUTIVE SUMMARY

This report presents results of the Valley-Specific Aggregate Resources Study (VSARS) for Tule Valley and surrounding areas in Utah. It is the eighth in a series of reports that contain aggregate information on the location and suitability of basin-fill and rock sources for concrete and road-base construction materials on a valley-specific basis. The findings presented are based on field reconnaissance and limited laboratory testing, existing data from the Utah State Department of Highways, and a previous regional aggregate investigation and Verification studies conducted by Ertec Western, Inc. (formerly Fugro National, Inc.).

A classification system based on aggregate type and potential use was developed to rank the suitability of all basin-fill and rock aggregate sources. Four aggregate types have been designated: coarse, fine, coarse and fine (multiple) aggregates derived from basin-fill sources, and crushed rock aggregates derived from rock sources. Each aggregate type was then classified using the following definitions:

Class I — Potentially suitable concrete aggregate or road-base material source;

Class II — Possibly unsuitable concrete aggregate/potentially suitable road-base material source; and

Class III — Unsuitable concrete aggregate or road-base material source.

Decisions on assigning a particular aggregate source to one of the three classes were determined from existing and Ertec

laboratory aggregate tests performed as part of this study (abrasion resistance, soundness, and alkali reactivity), and, to a lesser degree, from field visual observations.

Emphasis in this study is placed on the identificatio: and delineation of Class I basin-fill coarse aggregate. These deposits are considered to be the primary sources of concrete and road-base construction materials. Results of the study are presented on a 1:125,000-scale aggregate resources map (Drawing 2) and are summarized as follows:

1. Coarse Aggregate - Major Class I coarse aggregate deposits are located in the Tule Valley study area in:

    a. Alluvial fan (Aafg, Aafs) deposits west of the House Range and Fish Springs Range in eastern Tule Valley;

    b. Alluvial fan (Aafg) deposits bordering the Confusion Range in western Tule Valley; and

    c. Older lacustrine shoreline (Aolg, Aols) deposits throughout the valley.

Potentially suitable Class II coarse aggregate sources are widespread in the study area. They are typically located within alluvial fan (Aafs, Aafg) and older lacustrine (Aolg, Aols) deposits flanking Class I and/or Class II rock sources.

2. Fine Aggregates - Class I fine aggregate (multiple-type) sources were delineated in:

    a. Alluvial fan (Aafg) deposits east of the southern Confusion Range in southwestern Tule Valley; and

    b. Older lacustrine (A0lg, A0ls) deposits located throughout the valley basin.

Potential Class II fine aggregate sources typically occurring basinward of most Class I and Class II rock exposures are extensively distributed throughout the study area.

Many coarse aggregate basin-fill sources are also potential multiple sources (coarse and fine) that will supply varying quantities of fine aggregate either from the natural deposit or during processing.

3. Crushed Rocks - Abundant Class I crushed rock sources are present throughout the study area in:

a. Notch Peak and Guilmette formations (Cau) in the Confusion, Wah Wah, House, and Fish Springs ranges;

b. Fish Haven, Laketown, Sevy, and Simonson dolomites (Do) in the Confusion and Fish Springs ranges;

c. Prospect Mountain Quartzite (Qtz) in the northern House Range;

d. Marjum Limestone (Ls) in the northern House and southern Fish Springs ranges; and

e. Basalt (Vb) within northern Tule Valley.

The usability of any of these rock units as sources of crushed rock aggregate depends on their accessibility and minability within the study area.

Additional aggregate testing and field investigations will be required to further refine the lateral and vertical extents of classification boundaries and define exact physical and chemical characteristics of a particular deposit or rock source within the study area.

1.0 INTRODUCTION

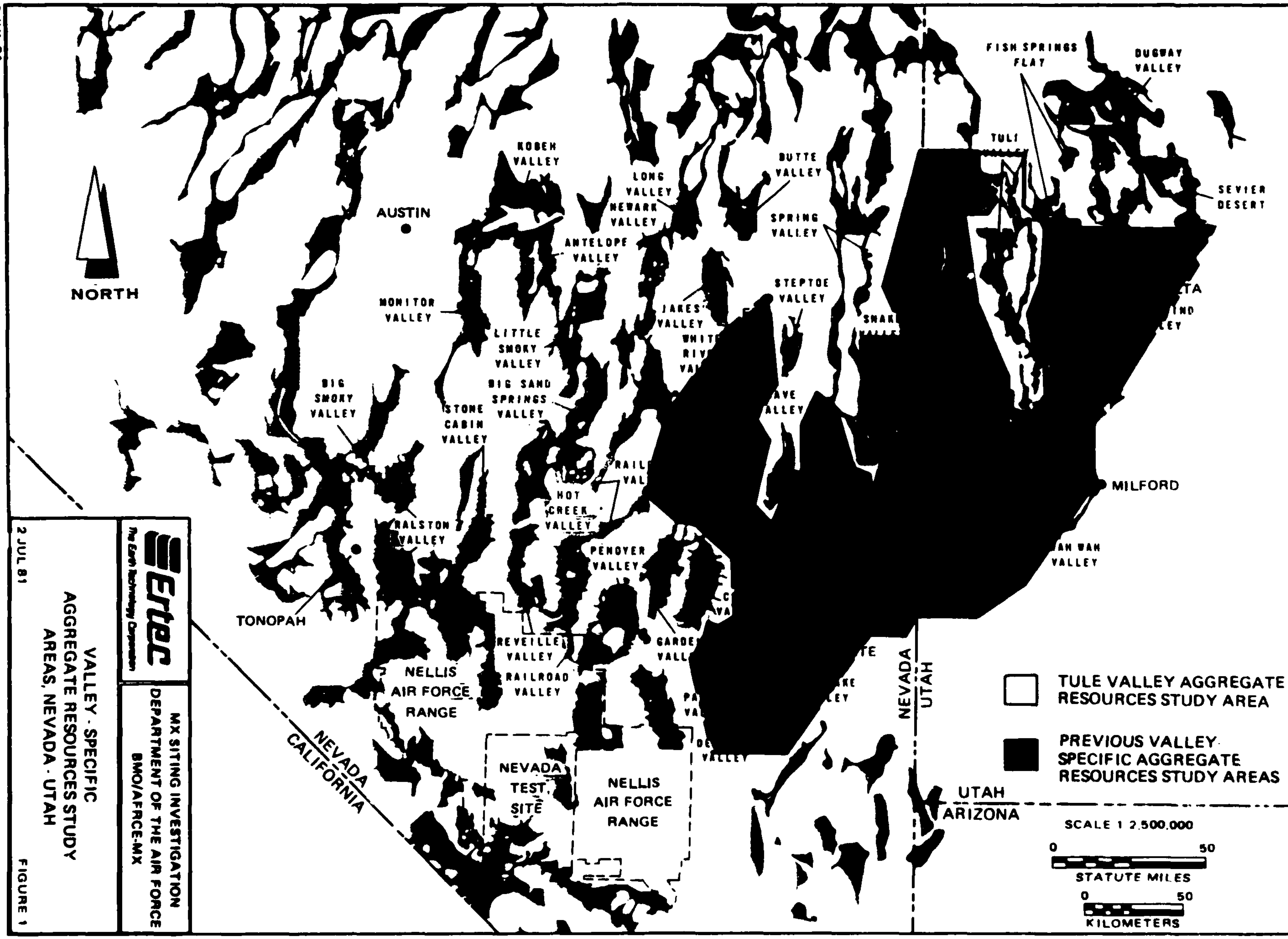
1.1 STUDY AREA

This report presents the results of the Valley-Specific Aggregate Resources Study (VSARS) completed for Tule Valley (Figure 1). Located in western Juab and Millard counties, Utah, the area contains a north-south trending alluvial basin flanked chiefly by sedimentary rock mountain ranges. Snake Valley and the Confusion and Wah Wah ranges border the site on the west, and the Fish Springs and House ranges mark the eastern boundary.

U.S. Highway 6 and 50 provide access to the central part of the study region. A network of unpaved roads and four-wheel-drive trails crisscross the study area (Drawing 1). The valley area is mainly comprised of undeveloped desert rangeland administered by the Bureau of Land Management (BLM).

1.2 BACKGROUND

The MX aggregate program began in 1977 with the investigation of Department of Defense (DoD) and BLM lands in California, Nevada, Arizona, New Mexico, and Texas (FN-TR-20D). Refinement of the MX siting area added portions of Utah and Nevada that were not studied in the initial Aggregate Resources Evaluation Investigation (AREI). This additional area (Figure 2), defined as the Utah Aggregate Resources Study Area (UARSA), was evaluated in the fall of 1979, and a second general aggregate resources report (FN-TR-34) was submitted on 3 March 1980. Both general aggregate investigations were designed to provide regional information of the general location, quality, and quantity of



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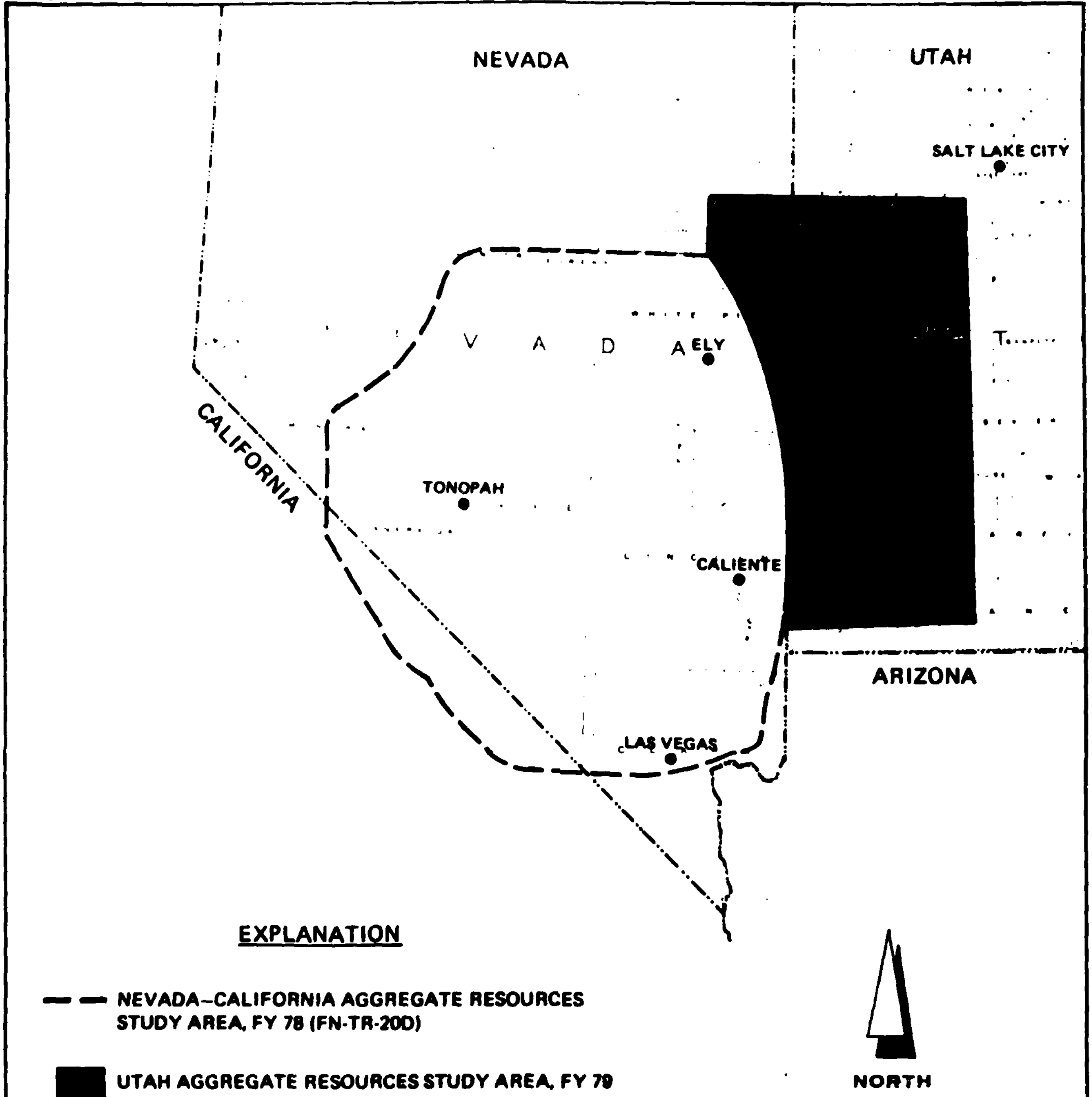
VALLEY - SPECIFIC
AGGREGATE RESOURCES STUDY
AREAS, NEVADA - UTAH

2 JUL 81

FIGURE 1



EXPLANATION

NEVADA–CALIFORNIA AGGREGATE RESOURCES STUDY AREA, FY 78 (FN-TR-20D)

UTAH AGGREGATE RESOURCES STUDY AREA, FY 79

SCALE 1:5,000,000

0 50 100 STATUTE MILES

0 50 100 KILOMETERS

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UTAH–NEVADA REGIONAL AGGREGATE STUDIES

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FIGURE 2

aggregates that could be used in the construction of the MX system.

Subsequent to the general studies, VSARS were developed in FY 79 and continued in FY 80 to provide more-detailed information on potential aggregate sources in specified valley areas (Figure 1).

1.3 OBJECTIVES

The primary objective of the VSARS program is to classify, on a valley basis, basin-fill and rock deposits for suitability as concrete and road-base construction materials. The VSARS format is designed to select and present the locations of the most acceptable aggregate sources for preliminary construction planning and follow-on, detailed aggregate investigations.

1.4 SCOPE

The scope of this investigation required office and field investigations and included the following:

1. Collection and analysis of available existing data on the quality and quantity of potential concrete aggregate and road-base material sources. American Society of Testing and Materials (ASTM) standards and Standard Specifications for Public Works Construction (SSPWC) were used to evaluate quality.

2. Aerial and ground reconnaissance of all identified potential aggregate sources in the valley area, with more-detailed investigation and sample collection of likely basin-fill (coarse and fine aggregates) and rock- (crushed-rock aggregates) construction material sources.

3. Laboratory testing to supplement available existing data and to provide detailed information to assist in determining the suitability of specific basin-fill or rock deposits as construction material sources within the valley area.

4. Development and application of an aggregate classification system (Section 2.5) that emphasizes aggregate type (coarse, fine, or crushed rock) and potential construction use (concrete and/or road base).

2.0 STUDY APPROACH

2.1 EXISTING DATA

Collection of existing test data from available sources was an important factor in the VSARS program. The principal source of existing data directly pertaining to aggregate construction materials was the Utah State Department of Highways (Appendix A). The majority of this information is related to the use of aggregate material for asphaltic concrete, base course in road construction, or ballast material; however, many of the suitability tests for these types of construction materials are similar to those for concrete and were applicable to this investigation (Appendix A).

2.2 SUPPLEMENTAL ERTEC WESTERN DATA

Supplemental Ertec data were obtained from: 1) field data and supplementary test data compiled during the general aggregate resources study (FN-TR-34), 2) Tule Valley Verification study (in progress), and 3) the current (Appendix A) and previous (FN-TR-37) Valley-Specific Aggregate Resources Studies.

The primary objective of the initial general aggregate study was a regional evaluation and ranking of all potential aggregate sources. Twenty-eight data points from the general aggregate study were located within the VSARS area (Drawing 1). These data stops supplied specific aggregate information which included two 150-pound samples collected for limited laboratory testing (Appendix A).

Verification geologic maps were an initial source of information on the type and extent of basin-fill units within specific valley areas. In addition, Verification study data included information from 22 trench locations distributed throughout the study area (Drawing 1). Depths of the selected trenches ranged from 8.5 to 14 feet (2.6 to 4.3 m). While the Verification studies are not specifically designed to generate aggregate data, the sampling techniques and testing procedures (Appendix A) are applicable to the aggregate evaluation.

The VSARS program required aerial and ground reconnaissance of the study area to collect additional information to verify conditions determined during the data review. Included in the 67 field station data stops was the collection of 26 samples for laboratory testing. Potential coarse and fine aggregate basin-fill samples were collected by channel sampling stream cuts or man-made exposures. Potential crushed-rock aggregate samples were obtained from exposures of fresh or slightly weathered material whenever possible. The weight of all laboratory samples collected ranged between 100 and 150 pounds. Rock hand samples, which generally did not exceed 5 pounds in weight, were collected for office analyses.

Identification of basin-fill materials in all field studies followed ASTM D 2488-69, Description of Soils (Visual-Manual Procedure), and the Unified Soil Classification System (Appendix C). Rock identifications followed procedures described in the Quarterly of the Colorado School of Mines (Travis, 1955)

and Standard Investigative Nomenclature of Constituents of Natural Mineral Aggregates (ASTM C 294-69).

2.3 DATA ANALYSIS

Geologic and engineering criteria were used in the evaluation of potential aggregate sources within the study area. This was supplemented by laboratory analysis of selected samples during the valley-specific aggregate testing program (Table 1). Coarse aggregate is defined as predominantly plus 0.185 inch (4.75 mm) fine gravel- to boulder-basin-fill material. Fine aggregate is defined as less than 0.375 inch (9.5 mm) and predominantly less than 0.185 inch (4.75 mm) and plus 0.0029 inch (0.074 mm) coarse to fine sand-basin-fill material. While all laboratory tests supplied definitive information, the abrasion, soundness, and alkali reactivity results were considered the most critical in determining the use and acceptability of a potential aggregate source.

2.4 PRESENTATION OF RESULTS

Study results are presented in text, tables, appendices, and two 1:125,000 scale maps. Drawing 1 presents the location of the 123 existing test data and supplemental Ertec data sites within the study area. Drawing 2 presents the location of all Ertec Western laboratory sample sites and all potential basin-fill and rock aggregate sources within the valley area. In addition, these potential aggregate sources are classified according to proposed aggregate use and type (Section 2.5).

ASTM TEST	SAMPLE TYPE AND NUMBER OF TESTS		
	COARSE	FINE	ROCK
ASTM C-88; SOUNDNESS BY USE OF MAGNESIUM SULFATE	16	17	8
ASTM C-131; RESISTANCE TO ABRASION BY USE OF THE LOS ANGELES MACHINE	14	NA	7
ASTM C-136; SIEVE ANALYSIS	18	17	NA
ASTM C-289; POTENTIAL REACTIVITY OF AGGREGATE (CHEMICAL METHOD)	4	5	4
ASTM C-127 AND C-128; SPECIFIC GRAVITY AND ABSORPTION	4	4	4

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AGGREGATE RESOURCES STUDY
AGGREGATE TESTS
TULE VALLEY, UTAH

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TABLE 1

Geologic unit symbols utilized in Drawing 2 relate to standard geological nomenclature whenever possible. Undifferentiated basin-fill and rock units were established primarily to accommodate accuracy of data and map scale and may contain deposits which could supply significant quantities of high-quality materials. A conversion table to relate these geologic symbols to the geologic unit nomenclature used in the Ertec Western Verification studies is contained in Appendix E.

All contacts which represent distinct boundaries between geologic units are shown as solid lines in Drawing 2. The contacts are dashed where the data were extrapolated beyond the limits of the source data or where accuracy of the data may be questionable. Local small deposits of one geologic unit may be found in close association with a larger deposit of a different geologic unit. Due to the reconnaissance level of the field investigation or scale limitations, these smaller deposits could not be depicted on the aggregate resources map and have been combined with the more prevalent material. Similarly, potential aggregate source classifications are preliminary and may contain lesser amounts of material of another use or type. Therefore, all classification lines are dashed and delimit the best aggregate evaluations possible at this level of investigation. In cases of highly variable rock or basin-fill units and limited aggregate tests, boundaries could not be drawn, and information is presented as individual sample data in Drawing 2.

Appendices contain tables summarizing the basic data collected during Ertec's supplemental field investigations, the results

of Ertec Western's supplemental testing programs, and existing test data gathered from various outside sources (Appendix A). Also included in appendices are an explanation of caliche development (Appendix B), the Unified Soil Classification System (Appendix C), photographs of typical aggregate sources within the study area (Appendix D), and a geologic unit cross-reference table (Appendix E).

2.5 PRELIMINARY CLASSIFICATION OF POTENTIAL AGGREGATE SOURCES

A system was developed to preliminarily classify all potential aggregate sources in the study area. This classification is designed to present the best potential sources of coarse, fine, coarse and fine (multiple source), and crushed-rock aggregate types within a valley-specific area (Drawing 2) based on potential aggregate use (Table 2). Concrete aggregate parameters are the principal consideration in this report since materials suitable for use as concrete aggregate are generally acceptable for use as road-base material. Therefore, the three classifications described below were based primarily on results of the abrasion, soundness, and alkali reactivity tests.

Class I — Potentially suitable concrete aggregate or road-base material source. Coarse and crushed-rock aggregates which either passed abrasion, soundness, and alkali reactivity tests or passed abrasion and soundness tests and were not tested for alkali reactivity; fine aggregates which either passed soundness and alkali reactivity tests or passed soundness tests and were not tested for alkali reactivity.

Class II — Possibly unsuitable concrete aggregate/potentially suitable road-base material source. Coarse, fine, and crushed-rock aggregates which either failed the soundness and/or alkali reactivity tests or were classified only by field visual observations or other test data.

AGGREGATE CHARACTERISTIC[1]			AGGREGATE USE CLASSIFICATION		
			CLASS I	CLASS II	CLASS III
ABRASION RESISTANCE, PERCENT WEAR[2]			< 50	< 50	> 50
SOUNDNESS, PERCENT LOSS[3]	COARSE AGGREGATE	$Na\ SO_4$	< 12	> 12	> 12
		$Mg\ SO_4$	< 18	> 18	> 18
	FINE AGGREGATE	$Na\ SO_4$	< 10	> 10	> 10
		$Mg\ SO_4$	< 15	> 15	> 15
POTENTIAL ALKALI REACTIVITY[4]			INNOCUOUS TO POTENTIALLY DELETERIOUS	DELETERIOUS	DELETERIOUS

1. AGGREGATE CHARACTERISTIC BASED ON STANDARD TEST RESULTS
2. ASTM C131 (500 REVOLUTIONS)
3. ASTM C88 (5 CYCLES)
4. ASTM C289

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PRELIMINARY AGGREGATE CLASSIFICATION SYSTEM, VALLEY-SPECIFIC AGGREGATE RESOURCES STUDY

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TABLE 2

Class III <u>Unsuitable concrete aggregate or road-base material source</u>. Coarse and crushed-rock aggregates which failed the abrasion test and were excluded from further testing. Fine, and rarely coarse aggregates composed of significant amounts of clay- and silt-sized particles.

Sources not specifically identified as Class I, II, or III from the three critical test results or have high clay- and silt-sized particle (less than .0029 inch [.074 mm]) content are designated as Class II sources. All classifications are preliminary with additional field reconnaissance, testing, and case history studies needed to confirm adequacy, delimit areal boundaries, and define exact physical and chemical characteristics.

The following publications/sources were used in defining the three use classifications:

1. ASTM C33-74A Standard Specifications for Concrete Aggregate;
2. SSPWC Part II Construction Sections 200-1.1, 1.4, 1.5, and 1.7;
3. Literature applicable to concrete aggregates;
4. Industrial producers of concrete aggregates; and
5. Consultants in the field of concrete aggregates.

3.0 GEOLOGIC SETTING

3.1 PHYSIOGRAPHY

The study area lies entirely within the Basin and Range Physiographic Province (Fenneman, 1946). Primary physiographic features are controlled by block faulting which has produced the uplifted north-south trending mountains and intervening down-dropped, alluvium-filled basins.

Four major mountain ranges bound the study area. These ranges are the Confusion and Wah Wah ranges on the west and the Fish Springs and House ranges on the east (Drawing 2). The Black Hills and Swasey Mountains form significant mountain ranges within the House Range. Topographic relief between mountain ridges and basins is generally greatest along the western valley margin where it averages approximately 3000 feet (914 m). Elevations within the valley range from less than 4300 feet (1310 m) near the northern end of Tule Valley to approximately 5200 feet (1585 m) in the extreme southern section of the study area.

Drainage in the main section of Tule Valley is closed to the central basin area. The extreme northern and southern parts of the study area drain into the Great Salt Lake Desert and the Wah Wah Valley Hardpan, respectively.

3.2 LOCATION AND DESCRIPTION OF GEOLOGIC UNITS

Rocks of the Paleozoic, Mesozoic, and Cenozoic eras are exposed within the study area. These rocks are of various igneous (intrusive and extrusive), metamorphic, and sedimentary lithologies (Drawing 2).

Paleozoic rocks are present throughout the study area. They consist predominantly of limestone and dolomite with appreciable thicknesses of orthoquartzite and minor thicknesses of interbedded sandstone, siltstone, and shale. Major exposures are located in all the mountain ranges throughout the study area.

Rocks of Mesozoic age are of limited areal extent within the study area. They consist of marine clastic sediments and intrusive igneous rocks. The marine sediments are thin- to thick-bedded calcareous marine shale with interbedded siltstone and sandstone. These rocks crop out in the northern Confusion Range. Intrusive igneous rocks consist of medium to coarse crystalline porphyritic granite exposed only in the central House Range.

Cenozoic rocks in the area consist predominantly of Tertiary igneous extrusives. These rocks are comprised of ashflow and air-fall tuffs and lava flows ranging in composition from basaltic to rhyolitic and are exposed in the extreme southern and northern parts of the study area.

Cenozoic basin-fill deposits unconformably overlie older units and consist primarily of alluvial fan, older lacustrine, stream-channel and terrace, and eolian deposits (Drawing 2). Alluvial fans are the most extensive and widespread deposit within the study area. These deposits reach a combined thickness of many hundreds to thousands of feet in the valley axis.

These geologic units have been grouped into eight rock units and four basin-fill units for use in discussing potential aggregate sources. Grouping of these units is based on similarities in physical and chemical properties and map-scale limitations. The resulting units allow for simplicity of discussion and presentation without altering the conclusions of this study.

3.2.1 Rock Units

Geologic rock units were grouped into the following eight categories (Drawing 2): quartzite (Qtz), limestone (Ls), dolomite (Do), carbonate rocks undifferentiated (Cau), sedimentary rocks undifferentiated (Su), granitic rocks (Gr), basalt (Vb), and volcanic rocks undifferentiated (Vu).

3.2.1.1 Quartzite - Qtz

Two quartzite units are present in the study area. They are the Cambrian Prospect Mountain Quartzite, and the Ordovician Eureka Quartzite.

The Cambrian Prospect Mountain Quartzite crops out in the northern House Range (Drawing 2). This formation is over 2000 feet (610 m) thick and consists of reddish-brown to white, thin- to thick-bedded, well-indurated, fine-grained orthoquartzite. The unit contains interbeds of less resistant quartzite, micaceous shale, pebble conglomerate, and arkosic sandstone layers.

The Ordovician Eureka Quartzite crops out locally in the southwestern portion of the study area within the southern Confusion Range (Drawing 2). It is generally less than 500 feet (165 m)

thick and is closely associated and often mapped with dolomitic rock (Do). The formation is white or light-gray in appearance, vitreous, fine- to medium-grained, massive orthoquartzite and quartz sandstone. Shale and dolomitic sandstone are exposed at the top and base of the formation.

3.2.1.2 Limestone - Ls

Limestone is a carbonate rock which is hard, durable, and forms resistant outcrops within the study area. Mapped units consist of the Cambrian Marjum, Weeks, and Orr formations, Ordovician Pogonip Group, and Mississippian Joana and Pennsylvanian Ely limestones. These units are typically thin- to thick-bedded, fine- to coarse-grained, light- to dark-gray limestone with interbedded chert, sandstone, siltstone, and shale. Locally, these units may be fossiliferous. Limestone units are mapped in the Wah Wah, Confusion, and House ranges.

3.2.1.3 Dolomite - Do

Dolomite, a high magnesium content carbonate rock, is an abundant lithologic unit in the Paleozoic section. Units mapped as dolomite are the Ordovician Fish Haven, Silurian Laketown, and the Devonian Sevy and Simonson formations. They are typically medium- to thick-bedded, fine- to coarse-grained, medium- to dark-gray dolomite with interbedded chert, sandstone, and siltstone. These units are exposed in the southern and northern Confusion Range and in the northern Fish Springs Range.

3.2.1.4 Carbonate Rocks Undifferentiated - Cau

Undifferentiated carbonate rock units comprise the largest portion of the Paleozoic section. They were mapped where complex, interbedded sequences of limestone and dolomite were present or where map scale prevented delineation of individual units. Principal mapped units include the Cambrian Notch Peak and Devonian Guilmette Formations and exposures of upper Paleozoic carbonate rocks. The lithology of these units varies considerably but is typically medium- to thick-bedded, fine- to medium-grained, medium- to dark-gray dolomite and limestone with interbedded chert and sandstone. Undifferentiated carbonate rocks crop out throughout the study area.

3.2.1.5 Sedimentary Rocks Undifferentiated - Su

Undifferentiated sedimentary rocks were mapped where interbedded sandstone, siltstone, shale, limestone, and/or dolomite are exposed. The highly interbedded nature of these units and map-scale limitations prevent separation into individual rock types. Principal units consist of numerous lower to upper Cambrian formations, the Devonian Pilot and Mississippian Chainman shales and the Permian Arcturus and Triassic Thaynes formations. Undifferentiated sedimentary rocks are exposed in the northern House Range and the Confusion Range.

3.2.1.6 Granitic Rocks - Gr

Granitic rocks of Mesozoic age are exposed in the central House Range. This unit is typically medium- to coarse-grained, moderately well-jointed, gray to brownish-gray porphyritic

granite. Large sills and small dikes extend into adjacent sedimentary rocks.

3.2.1.7 Basalt -Vb

Basaltic flows of Tertiary age are mapped in northern Tule Valley. The basalt is typically medium- to thick-bedded, very dense, brown to black, vesicular, and moderately well-jointed.

3.2.1.8 Volcanic Rocks Undifferentiated - Vu

Undifferentiated volcanic rocks consist of a variety of interlayered volcanic ashflow and air-fall tuffs and lava flows of Tertiary age. Composition ranges from basaltic to rhyolitic but is generally dacitic to rhyolitic. Volcanic units are extensively exposed at the southern end of Confusion and House ranges and in small isolated areas west of the Fish Springs Range.

3.2.2 Basin-fill Units

Four basin-fill units are mapped within the study area (Drawing 2). They consist of older lacustrine deposits (Aol), alluvial fan deposits (Aaf), stream-channel and terrace deposits (Aal), and undifferentiated deposits (Au). Gravel (g) and sand (s) grain-size designations (e.g., Aafg) have been assigned to basin-fill units in the Verification mapped areas. Basin-fill units which have high silt and/or clay content are considered unsuitable aggregate sources (Class III) and will not be discussed. These units are active playas, alluvial fans, or older lacustrine deposits located generally near the valley center.

3.2.2.1 Older Lacustrine Deposits - Aol

Widespread older lacustrine deposits in Tule Valley were formed during the existence of Pleistocene Lake Bonneville. Shoreline strand deposits are particularly well developed at elevations of approximately 4800 to 5200 feet (1440 to 1585 m) above mean sea level. These lacustrine deposits are typically poorly to moderately well-graded, moderately to well-stratified, loose to medium-dense sandy gravel and gravelly sand derived from quartzitic and carbonate source rocks. Clasts are subrounded to rounded; consist of gravel, cobbles, and boulders; and comprise between 18 and 87 percent of the deposit.

3.2.2.2 Alluvial Fan Deposits - Aaf

Alluvial fans bordering the mountain fronts and extending out into the valley basins are the most extensive potential basin-fill aggregate deposits mapped and labeled within the study area (Drawing 2). They are typically homogeneous to poorly stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay that grade from very coarse-grained near the rock/alluvium contact to fine-grained near the valley centers.

Individual fan units contain poorly to moderately well-graded, angular to subangular particles that exhibit considerable lateral and vertical textural variation. Composition of the surrounding source rock strongly controls the textural properties of material formed in alluvial fan deposits. Fan units formed at the base of carbonate or quartzitic rocks are characteristically coarse-grained, whereas fans developed from volcanic

sources tend to be fine-grained. Caliche development in soils (Appendix B), a natural process of soil development in arid climates, ranges from none in younger fans to Stage III in older units.

3.2.2.3 Stream-Channel and Terrace Deposits - Aal

Stream-channel and terrace deposits are widespread throughout the study area although most are too small to depict at the 1:125,000 map scale. Deposits that were mapped represent significantly large drainages and are typically poorly graded, moderately well-stratified sand with some gravel, cobbles, and boulders. Locally, these units may be predominantly gravel. Most ephemeral streams commonly transect alluvial fan deposits and trend normal to the ranges toward the valley axis. These streams join the trunk ephemeral drainage system in the central basin, which drain into the central valley hardpans of either Tule Valley, Wah Wah Valley, or the Great Salt Lake.

3.2.2.4 Alluvial Deposits Undifferentiated - Au

Undifferentiated alluvial deposits consist primarily of eolian deposits located in the central basin areas. These eolian deposits are stratified mixtures of sand and silt derived from a wide range of rock types.

4.0 POTENTIAL AGGREGATE SOURCES

Based on the results of field visual observations and aggregate testing, potential basin-fill and rock sources were divided into three basic material types (i.e., coarse, fine, and crushed rock) and classified into one of the three use categories (Section 2.5). Basin-fill deposits tested in the study area may also be placed within a multiple-type category (coarse and fine aggregate source). Coarse aggregate (gravel to boulders) included material predominantly retained on the No. 4 sieve (0.185 inch [4.75 mm]). Fine aggregate (predominantly sand) includes material entirely passing the 3/8-inch sieve (0.375 inch [9.5 mm]), almost entirely passing the No. 4 sieve (0.187 inch [4.75 mm]), and retained on the No. 200 sieve (0.0029 inch [0.074 mm]).

Classification boundaries (Drawing 2) of basin-fill aggregate sources were generalized and will require additional studies to accurately define their location. Boundaries of identified crushed-rock sources are based on the areal extent of the geologic formations tested (i.e., Prospect Mountain Quartzite, Fish Haven Dolomite) and not on the aggregate geologic unit (i.e., Qtz, Do) described in Section 3.2.1.

In the following discussion, coarse, fine, or crushed-rock sources are discussed in that order. Within these headings Class I sources are presented first, followed by sources with successively lower potential (Class II and Class III). Aggregate sources presented in Class I and Class II categories are

discussed in order of their relative potential (best followed by successively lower potential) as concrete or road-base aggregate sources. This ranking of deposits is preliminary and based upon an analysis of Ertec and existing data.

4.1 BASIN-FILL SOURCES

4.1.1 Coarse Aggregate

4.1.1.1 Potentially Suitable Concrete Aggregate or Road-Base Material Sources - Class I

In Tule Valley, Class I coarse aggregate sources are located in alluvial fan deposits (Aafg, Aafs) along the western side of the House Range and the Fish Springs Range (Drawing 2). These fan units are predominantly poorly to moderately well-stratified, medium-dense sandy gravel and gravelly sand composed predominantly of subangular to subrounded quartzite, limestone, and dolomite clasts. Laboratory tests show acceptable abrasion, soundness, and alkali reactivity (where tested) results (Table 2). Overburden, ranging from 1 to 3 feet (0.3 to 0.9 m), consists of soil horizons with Stage I to III caliche development. Sieve analyses of these samples indicate that the fan deposits are poorly to moderately well-graded and generally have oversize material for crushing. Fine aggregate material comprises from 17 to 71 percent of the tested samples. Good access to these deposits is provided by numerous unpaved roads which transect the area and connect with U.S. Highway 6 and 50 to the south. Minability is considered good to excellent. Class I boundaries are tentative, and additional field investigations will be necessary to accurately define the limits of these sources.

Extensive Class I coarse aggregate sources are also located along the western side of Tule Valley within alluvial fan (Aafg) deposits that border the Confusion Range (Drawing 2). Alluvial units consist predominantly of medium-dense to dense, poorly to moderately well-stratified sandy gravel composed predominantly of subangular carbonate clasts. Laboratory test data indicate these deposits have acceptable abrasion and soundness values for Class I coarse material (Table 2). Alkali reactivity tests were not performed on these samples. Sieve analyses indicate that the fan deposits are poorly graded and generally have sufficient oversize material for crushing. Fine aggregates comprise as much as 22 percent of the tested deposits. Overburdened averages 3 to 4.5 feet (1.0 to 1.3 m) thick and consists of slightly cemented gravel (Stages I to II caliche development). Access to these deposits is provided by U.S. Highway 6 and 50 which traverses the area and by numerous unpaved roads. Minability is considered good to excellent. Additional field reconnaissance and testing will be necessary to accurately define the boundaries of these potential sources.

Class I aggregate sources were identified in older lacustrine deposits (Aolg, Aols) throughout the basin (Drawing 2). Field observations indicate these deposits consist of poorly stratified to stratified, loose to medium-dense gravelly sand or sandy gravel. Gravel comprises from 34 to 87 percent of these sources and consists primarily of subrounded carbonate, quartzite, and sandstone clasts. These deposits passed abrasion, soundness and alkali reactivity (where tested) requirements for Class I

sources. Sieve analyses for these samples indicate that the deposits are typically well-graded and generally contain sufficient oversize material for crushing. Overburden ranged from 1 to 3 feet (0.5 to 0.9 m) consisting of slightly cemented sand and gravel (Stages I to II caliche development). Boundaries of these units are tentative where shown and will require additional field investigations for accurate definition. The access and minability of these sources varies with individual location but are generally considered good to excellent.

Field observations suggest that most alluvial fan units and older lacustrine shoreline units located basinward from the rock/alluvium contact of Class I and possibly Class II carbonate or quartzitic rocks may qualify as Class I coarse aggregate sources.

4.1.1.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material Sources - Class II

No Class II coarse aggregate sources were identified in the Tule Valley study area from laboratory test results. However, based on field observations, Class II coarse material is available in alluvial fan (Aafg, Aafs) and older lacustrine deposits (Aolg, Aols) throughout the valley area. Access and minability will vary but should generally be good.

4.1.1.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

No unsuitable coarse aggregate sources were identified in the Tule Valley study area.

4.1.2 Fine Aggregate

4.1.2.1 Potentially Suitable Concrete Aggregate or Road-Base Material Sources - Class I

A Class I fine aggregate source was delineated in alluvial fan deposits (Aafg) east of the southern Confusion Range. This area is mapped as a multiple source because of the presence of Class I coarse aggregates (Section 4.1.1.1). These deposits are poorly to moderately well-graded, medium-dense to dense, poorly to moderately well stratified sandy gravel with subangular clasts composed predominantly of dolomite and limestone. Sand comprises from 19 to 22 percent of the tested samples. Tests for soundness were within acceptable limits for Class I fine aggregate. Overburden is generally less than 3 feet (0.9 m) and consists of a soil horizon with Stage I to Stage II caliche development. Numerous unpaved roads transect the area and connect with U.S. Highway 6 and 50 to the north. Minability is considered very good.

Class I fine aggregate sources are located in older lacustrine deposits (Aolg, Aols) throughout the valley basin. Some of these deposits are also mapped as multiple sources because of the high Class I coarse aggregates content (Section 4.1.1.1). Deposits are typically poorly to moderately well-graded, poorly stratified to stratified, loose to medium-dense sandy gravel and gravelly sand composed predominantly of dolomite and limestone clasts. Gravel comprises from 18 to 75 percent of the deposits. Laboratory testing indicates acceptable soundness and alkali reactivity (where tested) results. Overburden consists of 0 to

3 feet (0 to 0.9 m) of poorly developed soil with Stage I to II caliche. Minability and access are considered good to excellent for these sources. Boundaries of Class I fine aggregate sources are tentative where shown and will require additional field investigations for accurate delimitation.

A Class I fine aggregate source was identified in a stream-channel deposit (Aals) on the east side of Tule Valley, 8 miles north of U.S. Highway 6 and 50. This unit is typically moderately well to well-graded, crudely stratified gravelly sand. Gravel comprises as much as 27 percent of this source with clasts composed predominantly of granite rock fragments. Soundness test results are within acceptable standards for Class I fine aggregate. The accessability and minability of this source is generally very good. Boundaries of this source could not be defined and will require additional field studies and testing to accurately define.

Based on field observations, additional Class I fine aggregate sources may exist in alluvial fans (Aafs, Aafg) located adjacent to Class I and/or Class II crushed-rock sources and in unmapped and mapped older lacustrine (Aolg, Aols) units.

4.1.2.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material Sources - Class II

Class II fine aggregate sources were identified from test results in alluvial fan (Aafs) and older lacustrine (Aolg, Aols) deposits throughout the study area. Tested samples failed to meet acceptable Class I standards for soundness and/or alkali

reactivity. The physical properties, composition, and source of these samples is variable. Field observations and laboratory test data for the sources are presented in Appendix A. Additional Class II fine aggregate sources should be available from most Class I and Class II basin-fill areas depicted in Drawing 2.

4.1.2.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

Class III fine aggregate sources are generally located in the central valley basins and are comprised predominantly of older lacustrine and recent playa deposits (Drawing 2). These sediments are typically interbedded, medium-dense fine sand and soft to stiff silt and clay.

4.2 CRUSHED-ROCK SOURCES

4.2.1 Potentially Suitable Concrete Aggregate or Road-Base Material Sources - Class I

Class I crushed-rock aggregate sources are distributed throughout the study area, occurring in the Confusion, Wah Wah, Fish Springs, and House ranges. Mapped units consist of undifferentiated carbonate rocks (Cau) of the Notch Peak and Guilmette formations; dolomite (Do) from the Laketown, Sevy, and Simonson formations; quartzite (Qtz) from the Prospect Mountain Formation; limestone (Ls) from the Marjum Formation; and basalt (Vb).

The Cambrian Notch Peak Formation (Cau) is exposed predominantly in the Wah Wah, Fish Springs, and House ranges (Drawing 2). It

is typically hard, medium- to thick-bedded, fine- to medium-grained, medium- to dark-gray interbedded limestone and dolomite. Locally, some interbedded shale is exposed. Laboratory data for the Notch Peak Formation indicate acceptable results for abrasion, soundness, and alkali reactivity. Test data from Wah Wah Valley (FN-TR-37-g) which lies south of the present study area indicate similar results. Accessibility and minability are good to excellent especially in the small hills in the central basin east of the Confusion Range.

The Devonian Guilmette Formation (Cau) was not tested within the study area but is considered a Class I source from test results in nearby Snake (FN-TR-37-b) and Hamlin (FN-TR-37-e) valleys. This unit is exposed in the northern and southern Confusion Range (Drawing 2). It consists of hard, thick-bedded, light- to dark-gray interbedded limestone and dolomite which may be locally sandy and/or silty. Field observations indicate that splitting characteristics are favorable for crushing. Accessibility and minability range from poor to good depending on location within the study area.

The Ordovician Fish Haven, Silurian Laketown, and Devonian Simonson and Sevy dolomites (Do) are exposed in the northern and southern Confusion Range and northern Fish Springs Range (Drawing 2). They consist primarily of dolomites with thin interbeds of chert, sandstone, siltstone, and sedimentary breccia. The dolomites are typically hard, medium- to thick-bedded, fine- to coarse-grained, medium- to dark-brown or gray and have favorable

splitting characteristics for crushing. Abrasion, soundness, and alkali reactivity tests (performed only on Fish Haven) indicate these units are within Class I standards for crushed-rock aggregates (Simonson and Fish Haven dolomites tested in Hamlin Valley, FN-TR-37-d; and Pine Valley, FN-TR-37-g; respectively). Alkali reactivity tests were not performed on the Laketown, Simonson and Sevy dolomites, however, field observations indicate potentially deleterious reactions may result from chert lenses and nodules occurring in these formations. The access and minability of these dolomites is considered good to excellent especially east of the Southern Confusion Range.

The Cambrian Prospect Mountain Quartzite (Qtz) was identified as a Class I crushed-rock source within the Swasey Mountains at the north end of the House Range (Drawing 2). Field observations indicate that the unit is very hard, thin- to thick-bedded, fine-grained, reddish-brown quartzite. The rock unit has slabby splitting characteristics and no deleterious materials. Abrasion, soundness, and alkali reactivity tests are within Class I standards for crushed-rock aggregate. Good to excellent access is provided by numerous unpaved roads. Minability is generally very good.

The Cambrian Marjum Formation (Ls) is exposed in the Swasey Mountains in northwestern Wah Wah Valley. The Marjum is hard, thin- to very thick-bedded, fine- to coarse-grained, dark-gray limestone with interbedded light-gray shaley dolomite in the upper part. Laboratory tested samples (Whirlwind Valley Report,

FN-TR-37-e; Pine and Wah Wah Valley Report, FN-TR-37-g) meet acceptable Class I standards for abrasion and soundness but were untested for alkali reactivity. Splitting characterisitics, minability, and accessibilty are moderately good to good.

Tertiary basalt exposed in northern Tule Valley is considered a Class I source. This unit consists of hard, medium- to thick-bedded, slightly vesicular, dark-brown basalt with moderately good splitting characteristics. Accessibility and minability are very good to excellent. The basalt was tested and found to meet Class I requirements for abrasion, soundness, and alkali reactivity.

4.2.2 Possible Unsuitable Concrete Aggregate/Potentially Suitble Road-Base Material - Class II

Class II crushed-rock aggregate sources were not specifically identified from the laboratory testing program. Extensive rock units, indicated in Drawing 2 as Class II crushed rock sources, were classified only by field visual observations. Paleozoic carbonates (Cau, Ls), undifferentiated sedimentary units (Su), and undifferentiated volcanics (Vu) comprise the predominant rock types in this category.

4.2.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

The Ordovician Eureka Quartzite (Qtz) within the Confusion Range in southern Tule Valley failed to meet Class I abrasion standards and is classified as a Class III source. This unit is a very hard, thin- to thick-bedded, white- or light-gray, fine- to medium-grained, massive orthoquartzite. Because this formation

has passed Class I crushed-rock requirements in northern Pine Valley (FN-TR-37-g), further field investigations will be necessary to accurately define its lithology and determine an overall classification.

5.0 CONCLUSIONS

Results of the valley-specific aggregate investigation indicate that potentially good- to high-quality (Class I and II) basin-fill and crushed-rock aggregate sources are present within the Tule Valley valley-specific area to meet construction requirements of the MX system (Drawing 2).

5.1 POTENTIAL BASIN-FILL AGGREGATE SOURCES

5.1.1 Coarse Aggregate

Major Class I coarse aggregate deposits listed in order of potential suitability, have been identified within the following areas:

1. Extensive alluvial fan (Aafg, Aafs) deposits west of the House Range and Fish Springs Range in the eastern part of the study area;

2. Extensive coarse alluvial fan (Aafg) deposits bordering the Confusion Range along the western side of the valley; and

3. Older lacustrine shoreline (Aolg, Aols) deposits throughout the valley basin.

Field observations and laboratory testing indicate additional sources of Class I coarse aggregate are available in alluvial fan deposits (Aafg, Aafs) adjacent to Class I and/or Class II crushed-rock sources and in older lacustrine deposits (Aolg, Aols) throughout the valley.

Based on field observation and limited test results, potentially suitable Class II coarse aggregate sources are widespread and extensive in the study area. Although boundaries of specific

deposits could not be delineated, they are typically located within older lacustrine deposits (Aolg, Aols) or alluvial fans (Aafg, Aafs) flanking Class I and/or Class II rock sources.

5.1.2 Fine Aggregate

While most coarse aggregate sources will supply quantities of fine aggregate (multiple source) either from the natural deposits or during processing, several fine aggregate sources were sampled and tested. They are:

1. Extensive alluvial fan (Aafg) deposits east of the southern Confusion Range;
2. Older lacustrine (Aolg, Aols) deposits located throughout the valley basin; and
3. A stream-channel (Aals) deposit west of the House Range in east-central Tule Valley.

Further field reconnaissance will be required to identify and delineate additional Class I fine aggregate sources, however, based on field observations, potential sources may exist in alluvial fan units (Aafg, Aafs) derived from Class I and/or Class II rock sources and in older lacustrine shoreline units (Aolg, Aols).

Potential Class II fine aggregate sources are widespread and extensive throughout the study area. Specific boundaries could not be delineated but typically occur in alluvial fan (Aafs, Aafg) and older lacustrine (Aolg, Aols) deposits basinward of most Class I and Class II rock exposures.

5.2 POTENTIAL CRUSHED-ROCK AGGREGATE SOURCES

Class I crushed-rock sources exist in several sections of the study area. The most suitable deposits and their corresponding

locations are as follows:

1. Fish Haven Laketown, Sevy, and Simonson dolomites (Do) and the Notch Peak and Guilmette formations (Cau) - Southern Tule Valley study area (southern Confusion and House ranges and the northern Wah Wah Range).

2. Notch Peak and Guilmette formations (Cau), Laketown, Sevy, and Simonson dolomites (Do) and basalt (Vb) - Northwestern Tule Valley study area (northern Confusion Range and adjacent valley areas).

3. Prospect Mountain Quartzite (Qtz), Marjum Limestone (Ls), Notch Peak Formation (Cau), and the Fish Haven Laketown, Sevy, and Simonson dolomites (Do) - Northeastern Tule Valley study area (northern House Range and the Fish Springs Range).

Carbonate (Cau, Do) Class I crushed-rock sources, exposed in southern Tule Valley (near Highway 6 and 50) and in small hills east of the Confusion Range, could provide crushed-rock material for much of the study area because of their good to excellent access and minability.

Undifferentiated volcanic rocks (Vu), limestone (Ls), and undifferentiated carbonate (Cau) and sedimentary rocks (Su), which are widely distributed throughout the study area, compose most of the Class II crushed-rock sources classified by field visual observations and delineated in Drawing 2.

6.0 BIBLIOGRAPHY

American Concrete Institute, 1977, Recommended practice for selecting proportions for normal and heavyweight concrete: American Concrete Institute, 20 p.

American Concrete Institute, 1978, Cement and concrete terminology: American Concrete Institute Publications, SP. 19 (78), 50 p.

American Public Works Assoc., 1970, Standard specifications for public works construction: Part 2 - Construction Materials, Sec. 200 Rock Materials, p. 62-70.

American Society for Testing and Materials, 1978, Annual book of ASTM standards, Part 14: Concrete and Mineral Aggregates, 814 p.

Barosh, Patrick James, 1960, Beaver Lake Mountains, Beaver County, Utah; their geology and ore deposits: Utah Geological and Mineralogical Survey Bulletin 68, 96 p.

Bates, R. L., 1969, Geology of the industrial rocks and minerals: Dover Publications, Inc., New York, 459 p.

Best, M. G., 1976, Geology map of the Lopers Spring quadrangle, Beaver County, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF 739.

Blanks, R., and Kennedy, H., 1955, The technology of cement and concrete, Vol. 1: John Wiley & Sons, Inc., 422 p.

Brown, L., 1959, Petrography of cement and concrete: Portland Cement Research Department, Bulletin 111.

Conrad, Omar G., 1969, Tertiary volcanic rocks of Needles Range, Western Utah: Utah Geological and Mineralogical Survey Special Studies 29, 28 p.

Erlin, B., 1966, Methods used in petrographic studies of concrete: Portland Cement Association, Research Department Bulletin 193, 17 p.

Ertec Western, Inc. (formerly Fugro National, Inc.) (in progress), Verification Studies, Tule Valley, Utah: Ertec Western Report E-TR-27-TL.

__________, 1981, Verification Studies, Pine Valley, Utah: Ertec Western Report E-TR-27-PI.

__________, 1981, Verification studies, Wah Wah Valley, Utah: Ertec Western Report E-TR-27-WA.

Fenneman, N. M., and D. W. Johnson, 1946, Physical divisions of the United States: U.S. Geological Survey map, scale 1:7,000,000.

Fix, P. F., and others, 1950, Ground water in the Escalante Valley, Beaver, Iron, and Washington counties, Utah: U. S. Geological Survey 27th Bicentennial Report p. 107-210.

Fugro National, Inc., 1978, Aggregate resources report, Department of Defense and Bureau of Land Mangement lands, southwestern United States, Fugro National Report FN-TR-20D, 85 p.

__________, 1980, Aggregate Resources Report, Utah-Nevada study area: Fugro National Report FN-TR-34, 36 p.

__________, 1980, Aggregate resources study, Snake Valley, Utah-Nevada: Fugro National Report FN-TR-37-b, 47 p.

__________, 1980, Aggregate resources study, Hamlin Valley, Nevada-Utah: Fugro National Report FN-TR037-d, 44 p.

__________, 1980, Aggregate resources study, Whirlwind Valley, Utah: Fugro National Report FN-TR-37-e, 43 p.

__________, 1981, Aggregate resources study, Pine Valley- Wah Wah, Utah: Fugro National Report FN-TR-37-g.

Gile, L. H., 1961, A classification of Ca horizons in soils in a desert region, Dona Ana County, New Mexico: Soil Science Society America Procedures, v. 25, No. 1, p. 52-61.

Hadley, D. W., 1961, Alkalai reactivity of carbonate rocks--expansion and dedolomitization: Research and Development Laboratories of the Portland Cement Association, Bulletin 139, p. 462-474.

__________, 1964, Alkalai reactivity of dolomitic carbonate rocks: Research and Development Laboratories of the Portland Cement Association, Bulletin 176, 19 p.

__________, 1968, Field and laboratory studies on the reactivity of sand-gravel aggregates: Research and Development Laboratories of the Portland Cement Association, Bulletin 221, p. 17-33.

Hayes, P. T., et al., 1977, Summary of the geology, mineral resources, engineering geology characteristics, and environmental geochemistry of east-central Utah: United States Geological Survey Open File Report No. 77-513, 135 p.

Heylmum, E. B., (ed.), 1963, Guidebook to the geology of southwestern Utah: Intermountain Association of Petroleum Geologists, Twelfth annual field conference, 232 p.

Hintze, L. F., 1974, Preliminary geologic map of the Conger Mountain quadrangle, Millard County, Utah: United States Geological Survey, MF 034.

______________, 1974, Preliminary geologic map of the Barn quadrangle, Millard County, Utah: United States Geological Survey Map, MF 633.

______________, (No date), Geologic History of Utah: Brigham Young Geology Studies, v. 20, part 3, 181 p.

______________, 1974, Preliminary geologic map Crystal Peak quadrangel, Millard County, Utah, United States Geological Survey Map, MF 635.

______________, 1974, Preliminary geologic map of the Notch Peak quadrangle, Millard County, Utah: United States Geological Survey Map, MF 636.

______________, 1974, Preliminary geologic map of the Wah Wah Summit quadrangle, Millard and Beaver Counties, Utah: United States Geological Survey Map, MF 637.

Hose, R. K., 1963, Geologic map and sections of the Cowboy Pass NE quadrangel, Confusion Range, Millard County, Utah: United States Geological Survey Map, I-377.

Hose, R. K., 1963, Geologic map and sections of the Cowboy Pass SE quadrangle, Confusion Range, Millard County, Utah: United States Geological Survey Map, I-391.

______________, 1965, Geologic map and sections of the Conger Range NE quadrangle and adjacent area, Confusion Range, Millard County, Utah: United States Geological Survey Map, I-436.

______________, 1965, Geologic map and sections of the Conger Range SE quadrangle and adjacent area, Confusion Range, Millard County, Utah: United States Geological Survey Map, I-435.

______________, 1974, Geologic map of the Trout Creek SE quadrangle, Jaub and Millard Counties, Utah: United States Geological Survey Map, I-827.

______________, 1974, Geological map of the Granite Mountain SW quadrangle, Juab and Millard Counties, Utah: United States Geological Survey Map, I-831.

Hose, R. K., and Repenning, C.A., 1963, Geologic map and sections of the Cowboy Pass NW quadrangle, Confusion Range, Millard County, Utah: United States Geological Survey Map, I-378.

_____________, 1964, Geologic map and sections fo the Cowboy Pass SW quadrangle, Confusion Range, Millard County, Utah: United States Geological Survey Map, I-390.

Hose, R. K., and Ziony, J. I., 1963, Geologic map and sections of the Gandy NE quadrangle, Confusion Range, Millard County, Utah: United States Geological Survey Map, I-376.

_____________, 1964, Geologic map and sections of the Gandy SE quadrangle, Confusion Range, Millard County, Utah: United States Geological Survey Map, I-393.

Howard, E. L., Compiler, 1978, Geology map of the eastern Great Basin, Nevada and Utah: Terra Scan Group LTD., 3 sheets.

Ketner, K. B., 1976, Map showing high-purity quartzite in California, Nevada, Utah, Idaho and Montana: United States Geological Survey Map, MF-821.

Lerch, W., 1959, A cement-aggregate reaction that occurs with certain sand-gravel aggregates: Research and Development Laboratories of the Portland Cement Association, Bulletin 122, p. 42-50.

McKee, E. D., and Weir, G. W., 1953, Terminology for stratification and cross-stratification in sedimentary rocks: Geological Society America Bulletin, v. 64, p. 381-389.

Mower, R. W. and R. M. Cordova, 1974, Water Resources of the Milford area, Utah, with emphasis on ground water: Utah Department National Resources Technical Publication 43, 106 p.

Murphy, J. B., Nichols, S. L., and Schilling, J. H., No date, Rockhound map of Nevada: Nevada Bureau of Mines and Geology, special publication 1.

National Sand & Gravel Association, 1977, Compilation of ASTM standards relating to sand, gravel and concrete: NSGA Circular No. 113, NRMCA Pub. No. 137.

Pickett, G., 1956, Effect of aggregate on shrinkage of concrete and hypothesis concerning shrinkage: Portland Cement Association, Research Department, Bulletin 66, 5 p.

Powers, T. C., and Steinour, H. H., 1955, An interpretation of published researches on the alkai-aggregate reaction: Research and Development Laboratories of the Portland Cement Association, Bulletin 55, Part I and II, p. 497, 785.

Roper, H., 1960, Volume changes of concrete affected by aggregate type: Portland Cement Association, Research Department Bulletin 123, 4 p.

Synder, C. T., Hardman, George, and Zdenek, F. F., 1964, Pleistocene lakes in the Great Basin: United States Geological Survey Map, I-416.

Steinour, H. H., 1960, Concrete mix water--how impure can it be? Research and Development Laboratories of the Portland Cement Association, Bulletin 119, p. 33-50.

Stephens, J. C., 1974, Hydrologic reconnaissance of the Wah Wah Valley drainage basin, Millard and Beaver counties, Utah: Utah Department Natural Resources Technical Publication 47, 53 p.

__________, 1976, Hydrologic reconnaissance of the Pine Valley drainage basin, Millard, Beaver, and Iron counties, Utah: Utah Department Natural Resources Technical Publication 51, 38 p.

Stokes, W. L., 1963, Geologic map of northwestern Utah: Utah Geology and Mineralogy Survey.

Stokes, W. L., and Heylmun, E. B., No Date, Outline of the geologic history and stratigraphy of Utah: Utah Geology and Mineral Survey, 36 p.

Stokes, W. L., and Heylmun, E. B., 1963, Tectonic history of southwestern Utah: IAPG Guidebook to the Geology of southwestern Utah, Heylmun, E. B., ed., 232 p.

Stokes, W. L., Peterson, J. A., and Picard, M. D., 1955, Correlation of Mesozoic formations of Utah: Bulletin American Association Petroleum Geology, v. 39, No. 10, p. 2003-2019.

Travis, R. B., 1955, Classification of rocks: Quarterly of the Colorado School of Mines, v. 50, No. 1, 98 p.

U. S. Department of the Interior, 1975, Concrete Manual: Water Resources Technical Publication, 627 p.

__________, 1974, The mineral industry of Nevada, Bureau of Mines.

__________, 1966, Concrete Manual: A manual for the control of concrete construction, Bureau of Reclamation 642 p.

__________, 1974, Earth Manual: United States Department of the Interior, Bureau of Reclamation, 810 p.

__________, 1975, Concrete Manual: United States Department of the Interior, Bureau of Reclamation, 627 p.

U. S. Geological Survey, 1969, Mineral and Water Resources of Utah: Report of the United States Geological Survey in cooperation with Utah Geological and Mineral Survey and the Utah Water and Power Board, Bulletin 73, 275 p.

Utah Department of Transportation, 1979, Standard specifications for road and bridge construction: Utah Department of Transportation, 531 p.

Utah Geological Association, 1972, Plateau-basin and range transition zone, central Utah: Utah Geological Association, Publication 2.

Utah Geological Association, 1973, Geology of Milford area: Utah Geology Association Pub. 3, 95 p.

Utah Geological Society, 1963, Beryllium and uranium mineralization in western Jaub County, Utah: Guidebook to the Geology of Utah, No. 7.

Utah Geological and Mineralogical Survey, 1969, Industrial minerals of Utah, map.

Utah Geological and Mineralogical Survey, 1970, A directory of the mining industry of Utah, 1967: Utah Geological and Mineralogical Survey, Bull 84, 38 p.

__________, 1975, Utah Mineral Industry Activity 1973 and 1974: Utah Geological and Mineralogical Survey, circ. 57, 8 p.

__________, 1979, Utah mineral industry operator directory, 1979: Utah Geological and Mineralogical Survey, 69 p.

Utah State Dept. of Highways, (1965), Materials inventory Jaub County, Utah: Utah State Department of Highways, 18 p.

__________, (1966), Materials inventory, Millard County, Utah: Utah State Department of Highways, 22 p.

Voskuil, W. H., 1966, Selected readings in mineral economics: Nevada Bureau of Mines, Report 12, 18 p.

Waddell, J., 1976, Concrete inspection manual: International Conference of Building Officials, 332 p.

Womack, J. C., et al., 1963, Materials manual: California Highway Transporation Agency, v. I and II.

APPENDIX A

ERTEC WESTERN FIELD STATION AND SUPPLEMENTARY TEST DATA AND EXISTING TEST DATA SUMMARY TABLES TULE VALLEY, UTAH

EXPLANATION OF ERTEC WESTERN FIELD STATION AND SUPPLEMENTARY TEST DATA

Ertec Western field stations were established at locations throughout the Valley-Specific Study Area where detailed descriptions of potential basin-fill or rock aggregate sources were recorded (Drawing 1). All field observations and laboratory test data on samples collected at selected stations are presented in Table A-1. Data entries record conditions at specific field station locations that have been generalized in the text and Drawing 2. Detailed explanations for the column headings in Table A-1 are as follows:

Column Heading	Explanation
Map Number	This sequentially arranged numbering system was established to facilitate the labelling of Ertec Western field station locations and existing data sites in Drawing 1 and to list the correlating information in Tables A-1 and A-2 in an orderly arrangement.
Field Station	Ertec Western field station data are comprised of information collected during: o The Valley-Specific Aggregate Resources Study; sequentially numbered field stations were completed by two investigative teams (A and B). o The general aggregate investigation in Utah (UGS). o The Verification study in Tule Valley; trench data (TL-T) were restricted to information below the soil horizon (3 to 12 feet [1 to 4 m]).
Location	Lists major physiographic or cultural features in/or near which field stations or existing data sites are situated.

Column Heading	Explanation
Geologic Unit	Generalized basin-fill or rock geologic units at field station or existing data locations. Thirteen classifications, emphasizing age and lithologic distinctions, were developed from existing geologic maps to accommodate map scale of Drawing 2.
Material Description	Except in cases where soil or rock samples were classified on laboratory results, the descriptions are based on field visual observations utilizing the Unified Soil Classification System (see Appendix C for detailed USCS information).
Field Observations	
Boulders and/or Cobbles, Percent	The estimated percentage of boulders and cobbles is based on an appraisal of the entire deposit. Cobbles have an average diameter between 3 and 12 inches (8 and 30 cm); boulders have an average diameter of 12 inches (30 cm) or more.
Gravel	Particles that will pass a 3-inch (76 mm) sieve and are retained on No. 4 (4.75 mm) sieve.
Sand	Particles passing No. 4 sieve and retained on No. 200 (0.075 mm) sieve.
Fines	Silt or clay, soil particles passing No. 200 sieve.
Plasticity (Index)	Plasticity index is the range of water content, expressed as percentage of the weight of the oven-dried soil, through which the soil is plastic. It is defined as the liquid limit minus the plastic limit. Field classification followed standard descriptions and their ranges are as follows: None - Nonplastic (NP) (PI, 0 - 4) Low - Slightly plastic (PI, 4 - 15) Medium - Medium plastic (PI, 15 - 30) High - Highly plastic (PI, > 31)
Hardness	A field test to identify materials that are soft or poorly bonded by estimating their resistance to impact with a rock hammer; classified as either soft, moderately hard, hard, or very hard.

Column Heading	Explanation
Weathering	Changes in color, texture, strength, chemical composition or other properties of rock outcrops or rock particles due to the action of weather; field classified as either fresh or slight(ly), moderate(ly) or very weathered.
Deleterious Materials	Substances potentially detrimental to concrete performance that may be present in aggregate; includes organic impurities, low-density material, (ash, vesicules, pumice, cinders), amorphous silica (opal, chert, chalcedony), volcanic glass, caliche coatings, clay coatings, mica, gypsum, pyrite, chlorite, and friable materials; also, aggregate that may react chemically or be affected chemically by other external influences.
Laboratory Test Data	
Sieve Analysis (ASTM C 136)	The determination of the proportions of particles lying within certain size ranges in granular material by separation on sieves of different size openings; 3-inches, 1 1/2-inches, 3/4-inch, 3/8-inch, No. 4, No. 8, No. 16, No. 30, No. 50, No. 100 and No. 200.
No. 8, No. 16, No. 30, No. 50	Asterisked entries used No. 10, No. 20, No. 40, and No. 60 sieves, respectively.
Abrasion Test (ASTM C 131)	A method for testing abrasion resistance of an aggregate by placing a specified amount in a steel drum (the Los Angeles testing machine), rotating it 500 times, and determining the material worn away.
Soundness Test (ASTM C 88) CA, FA	CA = Coarse Aggregate FA = Fine Agregate The testing of aggregates to determine their resistance to disintegration by saturated solutions of magnesium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

Column Heading	Explanation
Specific Gravity and Absorption (ASTM C 127 and 128)	Methods to determine the Bulk Specific Gravity, Bulk SSD Specific Gravity (Saturated - Surface Dry Basis), and Apparent Specific Gravity and Absorption as defined in ASTM E 12-70 and ASTM C 125, respectively.
Alkali Reactivity (ASTM C 289)	This method covers chemical determination of the potential reactivity of an aggregate with alkalies in portland cement concrete as indicated by the amount of reaction during 24 hours at 80°C between 1 N sodium hydroxide solution and aggregate that has been crushed and sieved to pass a No. 50 (300 m) sieve and be retained on a No. 100 (150 m) sieve.
Aggregate Use	I = Class I; potentially suitable concrete aggregate and road-base material source II = Class II; possibly unsuitable concrete aggregate/potentially suitable road-base material source III = Class III; unsuitable concrete aggregate or road base material source c = coarse aggregate f = fine aggregate f/c = fine and coarse aggregate cr = crushed rock All sources not specifically identified as Class I, II, or III from the abrasion, soundness, or alkali reactivity tests or the content of clay- and silt-sized particles are designated as Class II sources.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTI MATERIAL F THAN COBB PERCENT	
							GRAVEL	SAND
1	TL-A1	Tule Valley	Aolg	Sandy Gravel	GM			
2	TL-A2	Tule Valley	Aafs	Sandy Gravel	GP-GM	5	55	35
3	TL-A3	Tule Valley	Aolg	Gravelly Sand	SW-SM			
4	TL-A4	Tule Valley	Aolg	Gravelly Sand	SP-SM	T	35	60
5	TL-A5	Chalk Knoll	Cau	Limestone				
6	TL-A6	Tule Valley	Aolg	Sandy Gravel	GP-GM	T	55	40
7	TL-A7	Lodger Canyon	Aalg	Sandy Gravel	GP	3	60	35
8	TL-A8	Cowboy Pass	Aols	Gravelly Sand	SW			
9	TL-A9	Cowboy Pass	Aafs	Gravelly Sand	SP	T	40	60
10	TL-A10	Cowboy Pass	Aafs	Gravelly Sand	SW-SM			
11	TL-A11	Tule Valley	Aols	Gravelly Sand	SW-SM			
12	TL-A12	Tule Valley	Aolg	Sandy Gravel	GW			
13	TL-A13	Tule Valley	Aolg	Sandy Gravel	GP	10	65	35
14	Tl-A14	Tule Valley	Aafs	Gravelly Sand	GP-GM	0	40	50
15	TL-A15	Tule Valley	Aolg	Sandy Gravel/ Gravelly Sand	GP/SP	T	50	50

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASS						
BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS							
	GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	N[illegible] 1[illegible]
				Low			Caliche Coatings, Chert	100	87.6	63.3	45.2	34.8	27.4	[illegible]
5	55	35	10	None			None							
				None			Clay Coating		100	98.3	87.6	58.5	38.4	[illegible]
T	35	60	5	None			None							
					Hard	Slight to Moderate	Chert, Calcite Veins							
T	55	40	5	None			Chert							
3	60	35	5	None			Chert, Friable Material							
				None			Chert, Friable Material	97.7	93.7	91.2	82.9	65.9	54.6	[illegible]
T	40	60	T	None			Chert							
				Low			Chert, Caliche Coatings		98.1	96.3	85.0	62.4	44.4	[illegible]
				None			Chert, Caliche Coatings	100	99.4	97.4	93.2	81.6	58.3	[illegible]
				None			Caliche Coatings	100	98.4	90.2	68.8	33.6	25.9	
10	65	35	0	None			Caliche Coatings							
0	40	50	10	None			Caliche Coatings, Chert							
T	50	50	T	None			Caliche Coatings, Chert							

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LABORATORY TEST DATA

ALYSIS, PERCENT PASSING (ASTM C 136)								ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)						
											COARSE AGGREGATE				FINE AGGRE		
											SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVIT		
⅜"	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APP ENT
45.2	34.8	27.4	22.3	19.0	15.9	13.2	12.6	24.5	2.5	9.8							
87.6	58.5	38.4	24.5	16.2	11.8	9.3	6.9		3.6	9.1							
								38.4	14.6		2.63	2.66	2.71	1.15			
82.9	65.9	54.6	36.6	17.1	5.7	2.7	1.7	25.6	5.8	7.7					2.64	2.67	2.[illegible]
85.0	62.4	44.4	28.6	20.2	15.0	12.7	10.5		7.9	21.9							
93.2	81.6	58.3	26.5	13.6	10.5	8.7	5.4			15.0							
68.8	33.6	25.9	23.5	18.6	11.8	6.1	3.6	26.7	2.3	15.9							

CIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)							ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
GGREGATE		FINE AGGREGATE							
AVITY	PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION				
APPARENT		BULK	BULK SSD	APPARENT			CA	FA	
									Ic/f
									IIc/f
								Deleterious	IIf/c
									IIf/c
2.71	1.15						Innocuous		Icr
									IIc/f
									IIc/f
		2.64	2.67	2.73	1.30			Innocuous	If/c
									IIf/c
									IIf/c
									If
									Ic IIf IIc/f
									IIf/c
									IIc/f

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ERTEC WESTERN FIELD STATION
AND SUPPLEMENTARY TEST DATA
TULE VALLEY, UTAH

2 JUL 81 1 OF 8 TABLE A-1

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTI[ON OF] MATERIAL FI[NER] THAN COBB[LES,] PERCENT	
							GRAVEL	SAND
16	TL-B1	Tule Valley	Aolg	Sandy Gravel	GP			
17	TL-B2	Tule Valley	Su	Orthoquartzite				
18	TL-B3	Tule Valley	Aafg	Sandy Gravel	GW			
19	TL-B4	Blind Valley	Aalg	Sandy Gravel	GP	2	60	35
20	TL-B5	Barn Hills	Do	Dolomite				
21	TL-B6	Tule Valley	Aolg	Gravelly Sand	SW/GW			
22	TL-B7	Tule Valley	Aafs	Sandy Gravel	GW-GM			
23	TL-B8	Tule Valley	Aals	Gravelly Sand	SW			
24	TL-B9	Tule Valley	Ls	Limestone				
25	TL-B10	Swasey Mountains	Su	Limestone				
26	TL-B11	Tule Valley	Aafs	Gravelly Sand	SP	2	45	50
27	TL-B12	Tule Valley	Aafs	Gravelly Sand	SP	5	45	50
28	TL-B13	Tule Valley	Aafg	Sandy Gravel	GW			
29	Tl-B14	Tule Valley	Aafs	Gravelly Sand	SP	10	45	50
30	TL-B15	Tule Valley	Aafs	Sandy Gravel	GP	3	55	40
31	TL-B16	Tule Valley	Aolg	Sandy Gravel	GP-GM	T	50	40

S OL	FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PAS					
	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS						
		GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8
					Low			Caliche Coatings, Fines	100	85.8	41.0	25.5	21.1	
						Mod. Hard	Slight	None						
					None			Caliche Nodules	100	75.3	52.8	35.0	26.4	22.6
	2	60	35	5	None			Caliche Coatings						
						Hard	Slight	Chert						
W					None			Chert	100	99.5	91.7	75.4	50.8	34.6
M					Low			Fines	93.1	84.5	72.6	57.5	41.9	31.3
					None			None		100	99.0	94.9	73.4	50.2
						Hard	Slight	Calcite Veins						
						Hard	Slight	Calcite Veins						
	2	45	50	5	None			Caliche Coatings						
	5	45	50	5	None			Caliche Coatings						
					Low			Friable Material	96.5	85.7	62.9	35.2	18.2	13.0
	10	45	50	5	None			Caliche Coatings, Friable Material						
	3	55	40	5	None			Friable Material						
M	T	50	40	10	Low			Caliche Coatings						

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LABORATORY TEST DATA

LYSIS, PERCENT PASSING (ASTM C 136)								ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)						
											COARSE AGGREGATE				FINE AGGREGA		
											SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY		
⅜"	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT
5.5	21.1							20.0	1.4								
5.0	26.4	22.6	19.5	17.0	12.9	7.6	4.7	22.8	1.8	11.4							
								25.7	1.5								
5.4	50.8	34.6	18.5	10.8	5.1	1.6	0.9	39.9	2.8	13.0	2.67	2.69	2.72	0.59	2.60	2.64	2.71
7.5	41.9	31.3	22.8	16.9	12.4	9.1	6.2	30.7	4.7	14.2	2.78	2.80	2.84	0.66	2.63	2.67	2.73
4.9	73.4	50.2	27.9	14.4	6.9	3.9	2.5			9.5							
5.2	18.2	13.0	9.5	7.7	6.1	4.8	3.9	24.0	2.9	23.8							

	GRAVITY AND ABSORPTION (TM C 127 AND C 128)					ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
GATE		FINE AGGREGATE						
Y		SPECIFIC GRAVITY						
R-	PERCENT ABSORPTION	BULK	BULK SSD	APPAR-ENT	PERCENT ABSORPTION	CA	FA	
								Ic
								IIcr
								Ic/f
								IIc/f
								Icr
2	0.59	2.60	2.64	2.71	1.67	Innocuous	Innocuous	If/c
4	0.66	2.63	2.67	2.73	1.34	Innocuous	Innocuous	Ic/f
								If
								IIcr
								IIcr
								IIf/c
								IIf/c
								Ic IIf IIf/c
								IIc/f
								IIc/f

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2 JUL 81 2 OF 8 TABLE A-1

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
32	TL-B17	Tule Valley	Aafg	Sandy Gravel	GP-GM	T	50	40	10
33	TL-B18	Tule Valley	Aols	Gravelly Sand	SP	T	35	65	T
34	TL-B19	Tule Valley	Vb	Basalt					
35	TL-B20	Tule Valley	Aolg	Sandy Gravel	GP	T	52	48	T
36	TL-B21	Tule Valley	Do	Dolomite					
37	TL-B22	Granite Mountain	Cau	Limestone					
38	TL-B23	Confusion Range	Cau	Limestone & Sandstone					
39	TL-B24	Tule Valley	Aolg	Sandy Gravel	GP	2	52	48	T
40	TL-B25	Tule Valley	Aafs	Sandy Gravel	GP	3	55	40	5
41	TL-B26	Blind Valley	Aafg	Sandy Gravel	GP				
42	TL-B27	Blind Valley	Aafg	Sandy Gravel	GP	3	65	35	T
43	TL-B28	Tule Valley	Aafs	Sandy Gravel	GP	1	65	30	5
44	Tl-B29	Black Hills	Ls	Limestone					
45	TL-B30	Tule Valley	Aafs	Gravelly Sand	SP	0	48	52	T
46	TL-B31	Tule Valley	Aols	Gravelly Sand	SP-SM	2	44	46	10
47	TL-B32	Tule Valley	Aafs	Sandy Gravel	GP-GM	T	55	35	10
48	TL-B33	Tule Valley	Aolg	Sandy Gravel	GW				

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASSING (AS							
PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS								
	GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
	50	40	10	Low			Caliche Coatings								
	35	65	T	None			None								
					Hard	Slight	Volcanic Glass								
	52	48	T	None			None								
					Hard	Slight to Moderate	None								
					Hard	Slight	None								
					Hard	Slight	None								
	52	48	T	None			Chert								
	55	40	5	Low			Chert								
				None			None	100	90.9	61.2	35.5	22.3	16.4	13.3	11
	65	35	T	None			None								
	65	30	5	None			None								
					Hard	Slight	Chert								
	48	52	T	Low			Caliche Coatings, and Nodules								
	44	46	10	Low			Chert								
	55	35	10	Low			Caliche Coatings								
				None			Caliche Coatings	100	96.7	68.6	42.0	25.4	13.1	9.7	

LABORATORY TEST DATA

RCENT PASSING (ASTM C 136)							ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)							
										COARSE AGGREGATE				FINE AGGREGATE			
										SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION
	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT	
							23.4	0.7		2.81	2.82	2.83	0.24				
							24.1	0.8									
3	16.4	13.3	11.6	9.3	6.4	3.7	23.0	1.2	10.8								
							46.9	24.1									
4	13.1	9.7	2.6	1.9	1.6	1.3	23.7	1.7	6.9								

TY AND ABSORPTION 27 AND C 128)					ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
FINE AGGREGATE							
SPECIFIC GRAVITY				PERCENT ABSORPTION			
	BULK	BULK SSD	APPARENT		CA	FA	
							IIc/f
							IIf/c
					Innocuous		Icr
							IIc/f
							Icr
							IIcr
							IIcr
							IIc/f
							IIc/f
							Ic/f
							IIc/f
							IIc/f
							IIcr
							IIf/c
							IIf/c
							IIc/f
							Ic/f

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTI[ON OF] MATERIAL FI[NER] THAN COBBL[ES,] PERCENT	
							GRAVEL	SAND
49	TL-B34	Tule Valley	Aols	Sandy Gravel	GW-GM			
50	TL-B35	Tule Valley	Aafg	Sandy Gravel	GP	5	65	30
51	TL-B36	Tule Valley	Aols	Sandy Gravel	GW-GM			
52	TL-B37	Tule Valley	Aafs	Sandy Gravel	GP	12	60	40
53	TL-B38	Tule Valley	Aafs	Sandy Gravel	GP-GM			
54	TL-B39	Swasey Mountains	Qtz	Quartzite				
55	TL-B40	Tule Valley	Aolg	Sandy Gravel	GW			
56	WA-B1	Confusion Range	Cau	Dolomite				
57	WA-B2	Confusion Range	Qtz	Orthoquartzite				
58	WA-B3	Tule Valley	Vu	Intravolcanic Sandstone				
59	WA-B4	Black Hills	Ls	Limestone				
60	WA-B9	Grassy Cove	Ls	Limestone				
61	WW-A16	House Range	Ls	Limestone				
62	WW-A17	House Range	Gr	Granite				
63	WW-A18	House Range	Su	Limestone				

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PAS					
BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS						
	GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8
				None			Caliche Coatings	93.4	73.8	52.8	42.4	30.1	21.3
5	65	30	5	None			Caliche Coatings						
				None			None	90.2	79.3	67.8	54.7	41.4	29.0
12	60	40	T	None			Caliche Coatings						
				None			Friable Material	100	83.8	60.4	39.3	26.6	19.4
					Very Hard	Slight	None						
				None			Caliche Coatings		83.0	69.8	52.6	37.5	24.8
					Hard	Slight	Chert						
					Very Hard	Slight	None						
					Soft	Slight	Volcanic Glass & Ash, Friable Material						
					Hard	Slight	Chert						
					Hard	Slight	Chert, Calcite Veins						
					Very Hard	Slight	Chert, Friable Material						
					Very Hard	Moderate	None						
					Very Hard	Fresh	Chert						

LABORATORY TEST DATA

ANALYSIS, PERCENT PASSING (ASTM C 136)								ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPT (ASTM C 127 AND C 128)						
											COARSE AGGREGATE				FINE AGG		
											SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRA		
								PERCENT WEAR	PERCENT LOSS								
3/8"	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200		CA	FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	A
42.4	30.1	21.3	15.9	12.9	10.5	8.5	6.5	29.0	1.0	10.8	2.69	2.70	2.73	0.65			
54.7	41.4	29.0	21.6	16.7	12.1	8.6	6.1	25.8	1.7	8.7							
39.3	26.6	19.4	15.2	12.8	11.0	9.6	8.1	26.9	4.7	25.2	2.65	2.68	2.74	1.21			
								25.4	0.4		2.64	2.65	2.66	0.26			
52.6	37.5	24.8	13.8	10.3	3.0	1.3	0.9	20.4	0.7	7.8					2.78	2.80	[illegible]
								56.7									

ECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								
E AGGREGATE		FINE AGGREGATE				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
GRAVITY		SPECIFIC GRAVITY						
APPARENT	PERCENT ABSORPTION	BULK	BULK SSD	APPARENT	PERCENT ABSORPTION	CA	FA	
2.73	0.65					Innocuous		Ic/f
								IIc/f
								Ic/f
								IIc/f
2.74	1.21					Innocuous		Ic
								IIf
2.66	0.26					Innocuous		Icr
		2.78	2.80	2.83	0.54		Innocuous	Ic/f
								IIcr
								IIIcr
								IIcr
								IIcr
								IIcr
								IIcr
								IIcr
								IIcr

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ERTEC WESTERN FIELD STATION
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TULE VALLEY, UTAH

2 JUL 81 4 OF 8 TABLE A-1

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
64	WW-A22	House Range	Cau	Limestone					
65	WW-A24	House Range	Su	Limestone					
66	WW-B8	Swasey Mountains	Su	Limestone					
67	WW-B9	Tule Valley	Aafs	Sandy Gravel	GP	15	70	25	5
68	UGS-A8	Tule Valley	Aolg	Sandy Gravel	GW				
69	UGS-A9	Tule Valley	Aols	Sandy Gravel	GW				
70	UGS-A20	Barn Hills	Do	Dolomite					
71	UGS-A21	Black Hills	Cau	Limestone					
72	UGS-A22	Tule Valley	Aolg	Sandy Gravel	GP	0	80	20	T
73	UGS-A23	Tule Valley	Vu	Welded, Ash-flow Tuff					
74	UGS-A24	Barn Hills	Qtz	Quartzite & Sandstone					
75	UGS-A25	Barn Hills	Do	Dolomite					
76	UGS-A26	Barn Hills	Do	Dolomite					

FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (AS							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS								
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
				Very Hard	Slight	None								
				Very Hard	Fresh	Friable Material								
				Hard	Moderate	None								
70	25	5	None			Caliche and Clay Coatings								
			None			Caliche Coatings	100	99.0	85.1	44.1	13.4	6.8	4.2	3.
			None			Caliche Coatings	100	97.1	79.4	48.7	7.4	7.2	3.7	2.
				Very Hard	Fresh	Chert								
				Very Hard	Fresh	Chert								
80	20	T	None			Chert, Caliche Coatings								
				Very Hard	Fresh	Volcanic Glass and Pumice								
				Very Hard	Fresh	Friable Material								
				Very Hard	Fresh	Chert								
				Very Hard	Fresh	None								

LABORATORY TEST DATA

[P]ERCENT PASSING (ASTM C 136)						ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								
									COARSE AGGREGATE				FINE AGGREGATE				
									SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION	
NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT		
						28.3	6.73		2.97	2.98	3.02	0.57					Inm
6.8	4.2	3.7	3.5	2.4	0.5	22.2	0.73										
7.2	3.7	2.7	2.2	1.7	1.1	26.1	1.75										

AVITY AND ABSORPTION C 127 AND C 128)							
	FINE AGGREGATE				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
	SPECIFIC GRAVITY						
PERCENT ABSORPTION	BULK	BULK SSD	APPAR-ENT	PERCENT ABSORPTION	CA	FA	
0.57					Innocuous		Icr
							IIcr
							IIcr
							IIc
							Ic
							Ic
							IIcr
							IIcr
							IIc
							IIcr
							IIcr
							IIcr
							IIcr

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ERTEC WESTERN FIELD STATION
AND SUPPLEMENTARY TEST DATA
TULE VALLEY, UTAH

2 JUL 81 8 OF 8 TABLE A-1

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
77	UGS-A27	Tule Valley	Aolg	S[illegible]ndy Gravel	GP	T	90	10	T
78	UGS-A28	Middle Range	Ls	Limestone					
79	UGS-A29	Tule Valley	Aolg	Sandy Gravel	GP	T	60	40	T
80	UGS-A30	Fish Springs Range	Ls	Limestone					
81	UGS-A52	Crystal Peak	Vu	Ash-flow Tuff					
82	UGS-A53	Tule Valley	Aafs	Sandy Gravel/ Gravelly Sand	GP/SP	5	50	50	T
83	UGS-A94	Confusion Range	Do	Dolomite					
84	UGS-A95	Tule Valley	Aolg	Gravelly Sand	SP	0	40	55	5
85	UGS-A96	Tule Valley	Aalg	Sandy Gravel	GP	T	55	45	T
86	UGS-A97	Plympton Ridge	Cau	Limestone					
87	UGS-A98	Tule Valley	Aols	Gravelly Sand	SP	T	35	65	T
88	UGS-A99	Granite Mountain	Cau	Limestone					
89	UGS-B15	Fish Spring Range	Vb	Basalt					
90	UGS-B21	Coyote Knolls	Ls	Limestone					

FIELD OBSERVATIONS														
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS	SIEVE ANALYSIS, PERCENT PASSING (AST							
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
90	10	T	None			Mica								
				Mod. Hard	Moderate	Chert								
60	40	T	None			Chert								
				Hard	Slight	Calcite Veins								
				Soft	Slight	Volcanic Glass and Ash								
50	50	T	None			Caliche Coatings								
				Very Hard	Fresh	None								
40	55	5	None			None								
55	45	T	None			None								
				Hard	Slight	Chert, Calcite Veinlets								
35	65	T	None			Chert, Caliche Coatings								
				Very Hard	Slight	Calcite Veinlets								
				Very Hard	Slight	Vesicules								
				Very Hard	Slight	Chert								

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LABORATORY TEST DATA

. PERCENT PASSING (ASTM C 136)							ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)							
										COARSE AGGREGATE				FINE AGGREGATE			
										SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION
NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT	

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FIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)						ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
REGATE		FINE AGGREGATE						
VITY	PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION			
PPAR-ENT		BULK	BULK SSD	APPAR-ENT		CA	FA	
								IIc
								IIcr
								IIc/f
								IIcr
								IIcr
								IIc/f
								IIcr
								IIf/c
								IIc/f
								IIcr
								IIf/c
								IIcr
								IIcr
								IIcr

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ERTEC WESTERN FIELD STATION
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TULE VALLEY, UTAH

2 JUL 81 6 OF 8 TABLE A-1

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
91	UGS-B26	Swasey Mountains	Qtz	Orthoquartzite					
92	UGS-B27	Tule Valley	Do	Dolomite					
93	UGS-B28	Tule Valley	Aafg	Sandy Gravel	GP	5	60	40	T
94	UGS-B55	Gray Hills	Do	Dolomite					
95	UGS-B56	Tule Valley	Aafs	Gravelly Sand	SP	5	45	55	T
96	TL-T1	Tule Valley	Aols	Silty Sand	SM	0	25	45	30
97	TL-T2	Tule Valley	Aols	Sandy Gravel	GM				
98	TL-T3	Tule Valley	Unsuit-able	Sandy Silt	ML		0	8	92
99	TL-T4	Tule Valley	Aols	Sandy Gravel	GM	10	50	36	14
100	TL-T7	Tule Valley	Aafs	Sandy Gravel	GP-GM		50	40	10
101	TL-T8	Tule Valley	Aolg	Gravelly Sand	SM-GM		45	48	7
102	TL-T9	Tule Valley	Aolg	Sandy Gravel	GP				
103	TL-T10	Tule Valley	Aafs	Sandy Gravel	GP-GM				
104	TL-T11	Tule Valley	Aafs	Gravelly Sand	SM				
105	TL-T12	Tule Valley	Aafg	Sandy Gravel	GM		45	40	15
106	Tl-T13	Tule Valley	Aafs	Gravelly Sand	SW-SM				

	FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT					
AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT: GRAVEL	SAND	FINES	PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS	3"	1½"	¾"	⅜"	NO. 4	NO. 8
					Very Hard	Slight	None						
					Hard	Slight	Chert						
5	60	40	T	None			Caliche Coatings						
					Hard	Slight	Chert						
5	45	55	T	None			Caliche Coatings						
0	25	45	30	Low			Caliche Coatings						
				None			Caliche Coatings			90.6	71.6	49.9	36.
	0	8	92	Low			Caliche Coatings						
0	50	36	14	None									
	50	40	10	None			Caliche Coatings and Nodules						
	45	48	7	None			Low Density Volcanics						
				None			Low Density Volcanics		93.8	71.2	27.8	7.1	3.
				None			Caliche Coatings			95.0	81.1	51.3	28.
				Low			Caliche Coatings, Low Density Volcanics			98.5	93.7	79.9	64.
	[illegible]	[illegible]	15	Low			Caliche Coatings						
				Low			Caliche Coatings			97.1	89.6	70.3	54.

LABORATORY TEST DATA

...YSIS, PERCENT PASSING (ASTM C 136)								ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)						
											COARSE AGGREGATE				FINE AGGREGATE		
											SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY		
									PERCENT LOSS								
-	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	CA	FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT
.6	49.9	36.4*	29.9*	26.3*	20.9*	17.5	14.9										
.8	7.1	3.8*	3.1*	2.6*	2.3*	1.7	0.9										
.1	51.3	28.8*	17.7*	13.1*	10.9*	9.5	7.8										
.7	79.9	64.4*	49.9*	40.5*	33.7*	28.2	21.0										
6	70.3	54.2*	39.1*	25.9*	16.3*	11.4	8.6										

…ITY AND ABSORPTION …127 AND C 128)								
	FINE AGGREGATE				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
	SPECIFIC GRAVITY						
ABSORPTION	BULK	BULK SSD	APPAR-ENT	PERCENT ABSORPTION	CA	FA	
							IIcr
							IIcr
							IIc/f
							IIcr
							IIf/c
							IIf/c
							IIc/f
							IIIf
							IIc/f
							IIc/f
							IIf/c
							IIc
							IIc/f
							IIf/c
							IIc/f
							IIf/c

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ERTEC WESTERN FIELD STATION
AND SUPPLEMENTARY TEST DATA
TULE VALLEY, UTAH

2 JUL 81 | 7 OF 8 | TABLE A-1

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT		
							GRAVEL	SAND	FINES
107	TL-T14	Tule Valley	Aols	Sandy Gravel	GP		76	20	4
108	TL-T15	Tule Valley	Aafs	Gravelly Clay	CL		35	5	60
109	TL-T16	Tule Valley	Aafs	Sandy Gravel	GM				
110	TL-T17	Tule Valley	Aafs	Sandy Gravel	GP-GM				
111	TL-T18	Tule Valley	Aafg	Sandy Gravel	GP-GM	T	50	40	10
112	TL-T19	Tule Valley	Aafs	Silty Sand	SM	5	4	48	48
113	TL-T20	Tule Valley	Aafs	Gravelly Sand	SM		30	55	15
114	TL-T21	Tule Valley	Aols	Silty Sand	SM		10	70	20
115	TL-T22	Blind Valley	Aafg	Sandy Gravel	GP-GM				
116	TL-T23	Tule Valley	Aafg	Sandy Gravel	GP				
117	TL-T24	Tule Valley	Aafs	Gravelly Sand	SM		35	45	20

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASSIN[G]						
[BOULDERS] AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS							
	GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16
	76	20	4	None			Caliche Coatings and Nodules							
	35	5	60	Med.										
				Low			Low Density Volcanics		91.4	79.7	53.7	34.3	28.0*	24.7
				None			Caliche Coatings			98.2	77.4	22.3	9.0*	7.[illegible]
T	50	40	10	None										
5	4	48	48	Low										
	30	55	15	Low			Caliche Coatings							
	10	70	20	Low			Caliche Coatings							
				None					70.4	52.4	40.7	34.7	30.7*	28.[illegible]
				None			Caliche Coatings			96.8	76.1	50.1	37.6*	30.[illegible]
	35	45	20	Low										

LABORATORY TEST DATA

YSIS, PERCENT PASSING (ASTM C 136)								ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)						
											COARSE AGGREGATE				FINE AGGREGA		
									PERCENT LOSS		SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY		
¾"	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	CA	FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT
3.7	34.3	28.0*	24.7*	22.7*	21.0*	19.4	16.9										
7.4	22.3	9.0*	7.8*	7.4*	7.1*	6.5	5.4										
0.7	34.7	30.7*	28.2*	24.9*	20.0*	15.0	11.0										
6.1	50.1	37.6*	30.3*	24.8*	20.0*	6.0	3.2										

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Coarse Aggregate (cont.): Percent Absorption	Fine Aggregate: Specific Gravity: Bulk	Fine Aggregate: Specific Gravity: Bulk SSD	Fine Aggregate: Specific Gravity: Apparent	Fine Aggregate: Percent Absorption	Alkali Reactivity (ASTM C 289): CA	Alkali Reactivity (ASTM C 289): FA	Aggregate Use
							IIc
							IIIf
							IIc
							IIc
							IIc/f
							IIf
							IIf/c
							IIf
							IIc/f
							IIc/f
							IIf/c

(Table header as printed: ... GRAVITY AND ABSORPTION ... C 127 AND C 128)

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ERTEC WESTERN FIELD STATION AND SUPPLEMENTARY TEST DATA
TULE VALLEY, UTAH

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EXPLANATION OF EXISTING DATA

Existing data pertaining to aggregates were extracted from the Utah State Department of Highways' Materials Inventory county reports. These reports are compilations of avaiable site data from existing files and records and are intended to accurately locate, investigate, and catalog materials needed for highway construction. Explanations for column headings which appear in Table A-2, that have not been previously discussed in Table A-1, are given below.

Column Heading	Explanation
Site Number	Utah State Department of Highways pit or site number. Locations correspond to map numbers listed on this table and placed in Drawing 2.
Material Description USCS Symbol	To maintain conformity within the study, the Utah State Department of Highways classification system (A.A.S.H.O.) was converted to the Unified Soil Classification System (USCS) utilizing the sieve analyses' size distribution and the plasticity indices.
Sieve Analysis	The size distribution of fine and coarse aggregate samples was determined by sieving. In some samples, particles greater than 1 inch in size (>1 inch) were crushed to 1 inch maximum size and remixed with the remaining sample before sieving. In these cases, data entries under 1 inch are 100 percent, preceded by before-crushing percentages.
No. 10, No. 40	Samples tested after mid-1963 used No. 8 and No. 50 sieves, respectively. These entries are marked with asterisks.
Soundness Test	The testing of aggregates to determine their resistance to disintegration by saturated solutions of sodium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action,

Column Heading	Explanation
Soundness Test (cont.)	particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

MAP NUMBER	SITE NUMBER	DATA SOURCE	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	US SYM
118	14098	USDH Millard Co.	Tule Valley	Aafs	Sandy Gravel	GP
119	14099	USDH Millard Co.	Tule Valley	Aafs	Sandy Gravel	GP-
120	14100	USDH Millard Co.	Tule Valley	Aafs	Sandy Gravel	GP-
121	14101	USDH Millard Co.	Tule Valley	Aols	Sandy Gravel	GP
122	14102	USDH Millard Co.	Tule Valley	Aolg	Sandy Gravel	GP-
123	14103	USDH Millard Co.	Tule Valley	Aafg	Sandy Gravel	GP-

USCS SYMBOL	SIEVE ANALYSIS — BEFORE CRUSHING, PERCENT		SIEVE ANALYSIS — PERCENT PASSING AFTER CRUSHING TO 1" MAXIMUM SIZE						ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88) PERCENT LOSS		PLASTICITY INDEX (ASTM D 423 and D 424)
	>3"	>1"	1"	½"	NO. 4	NO. 10	NO. 40	NO. 200	PERCENT WEAR	CA	FA	
GP	0	28.6	100		38.9	31.5	13.7	2.1	24.4			NP
GP-GM	18.5	31.8	100		30.4	22.7	16.6	7.8	18.7			NP
GP-GM	0	10.3	100	81.6	49.7	31.7*	8.2*	6.8	25.1			NP
GP		44.0	100		24.6	18.9	8.7	1.6	22.1			NP
GP-GM	0	17.6	100		42.6	23.8	15.8	7.7	16.6			NP
GP-GM		13.4	100		47.0	29.3	14.3	6.0	22.1			2

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EXISTING TEST DATA
TULE VALLEY, UTAH

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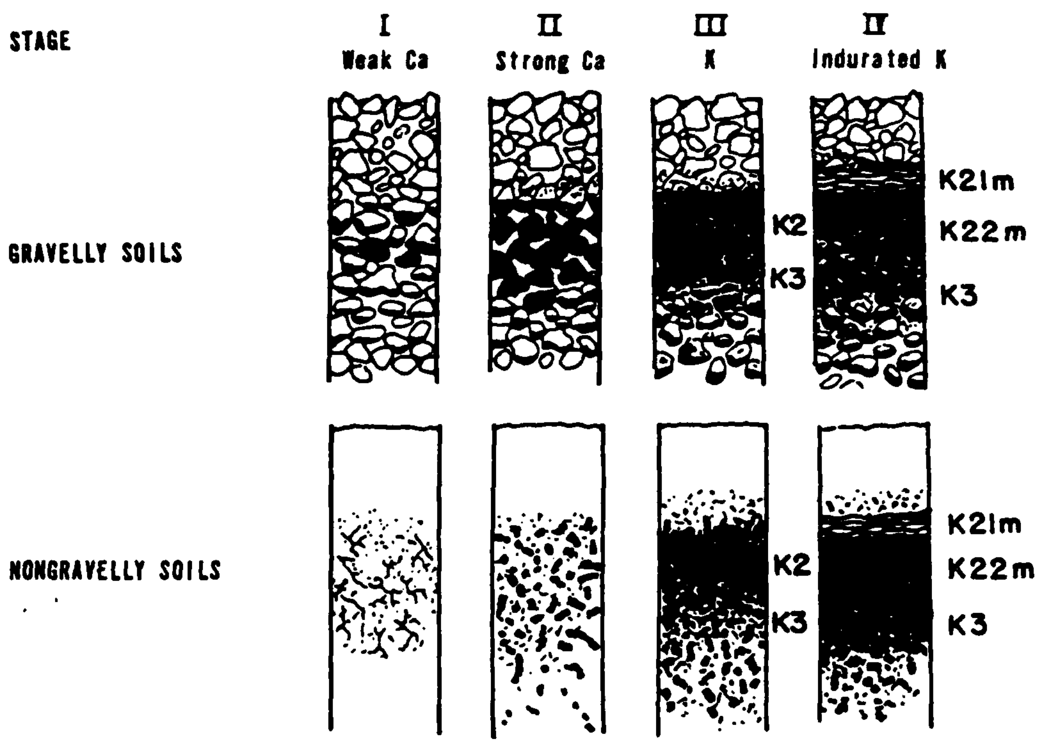
APPENDIX B

SUMMARY OF CALICHE DEVELOPMENT

DIAGNOSTIC CARBONATE MORPHOLOGY

STAGE	GRAVELLY SOILS	NONGRAVELLY SOILS
I	Thin, discontinuous pebble coatings	Few filaments or faint coatings
II	Continuous pebble coatings, some interpebble fillings	Few to abundant nodules, flakes, filaments
III	Many interpebble fillings	Many nodules and internodular fillings
IV	Laminar horizon overlying plugged horizon	Laminar horizon overlying plugged horizon



Reference: Gile, L.M, Peterson, F.F., and Grossman, R.B., 1965. The K horizon: A master horizon of carbonate accumulation: Soil Science, v. 99, p. 74–82.

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SUMMARY OF CALICHE DEVELOPMENT

2 JUL 81

APPENDIX C

UNIFIED SOIL CLASSIFICATION SYSTEM

AD-A112 975 ERTEC WESTERN INC LONG BEACH CA F/G 8/7
MX SITING INVESTIGATION. AGGREGATE RESOURCES STUDY, TULE VALLEY--ETC(U)
JUL 81 F04704-80-C-0006
UNCLASSIFIED E-TR-37-H NL

2 OF 2
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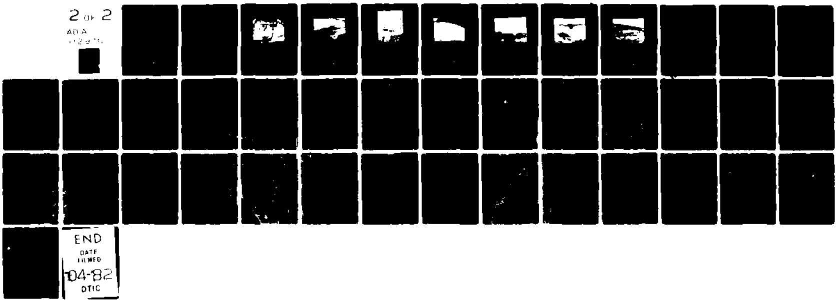
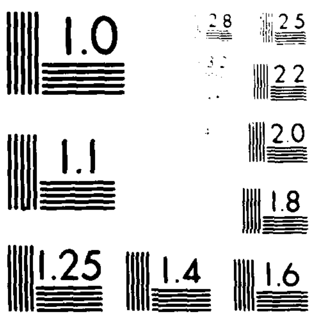


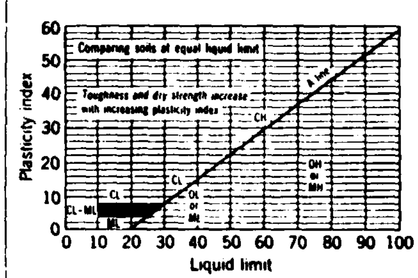


MICROCOPY RESOLUTION TEST CHART

Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)				Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria		
Coarse-grained soils More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	Use grain size curve in identifying the fractions as given under field identification	Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines				Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures				Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics			Atterberg limits above "A" line, with *PI* greater than 7
	Sands More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)			$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines				Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures				Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures				Atterberg limits below "A" line with *PI* greater than 7

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Fine-grained soils More than half of material is *smaller* than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to naked eye)	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart for laboratory classification of fine grained soils

From Wagner, 1957.
[a] *Boundary classifications.* Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.
[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking):
After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.
Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.
Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics):
After removing particles larger than No. 40 sieve size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.
High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit):
After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.
After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.
The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.
Highly organic clays have a very weak and spongy feel at the plastic limit.

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UNIFIED SOIL CLASSIFICATION SYSTEM

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APPENDIX C

APPENDIX D

TULE VALLEY
STUDY AREA PHOTOGRAPHS

Alluvial Fan Deposit (Aafs) in east central Tule Valley;
Class I coarse aggregate source (Station 53).

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TULE VALLEY
STUDY AREA PHOTOGRAPH

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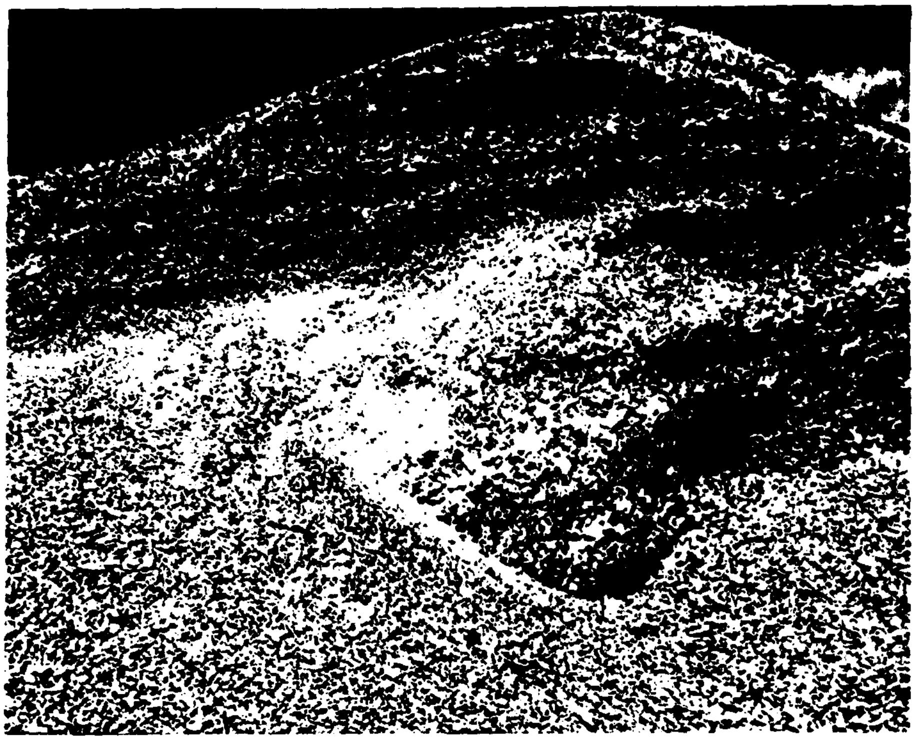
FIGURE D 1



Older Lacustrine Shoreline Deposit (Aolg) along east central Tule Valley;
Class I coarse aggregate source (Station 68).

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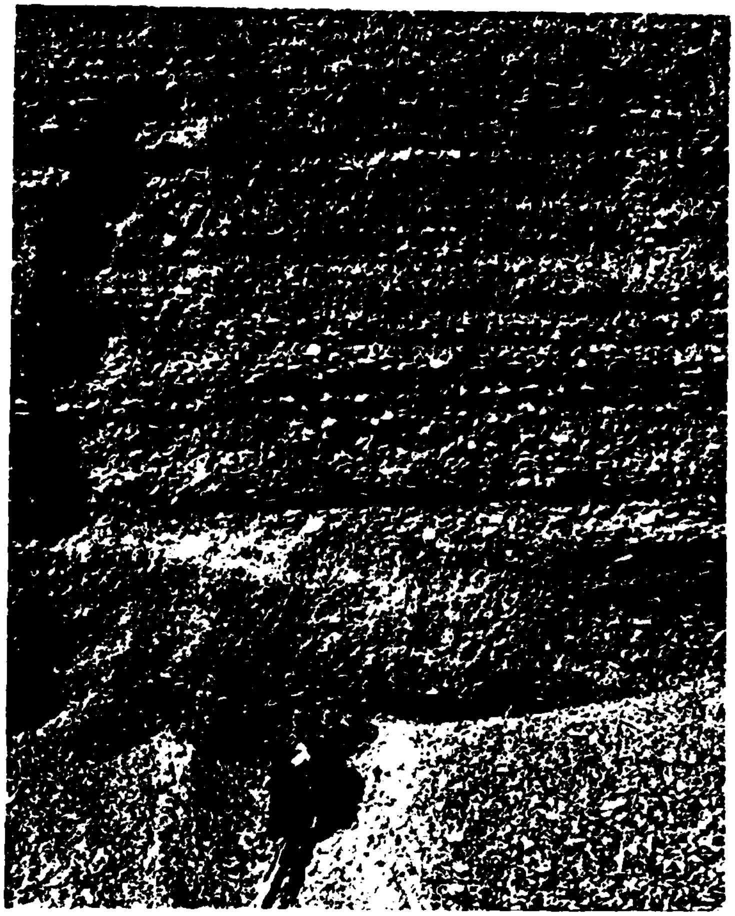
TULE VALLEY STUDY AREA PHOTOGRAPH	
2 JUL 81	FIGURE D-2



Older Lacustrine Deposit (Aolg) in southern Tule Valley;
Class I coarse and fine (multiple) aggregate source (Station 21).

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TULE VALLEY
STUDY AREA PHOTOGRAPH

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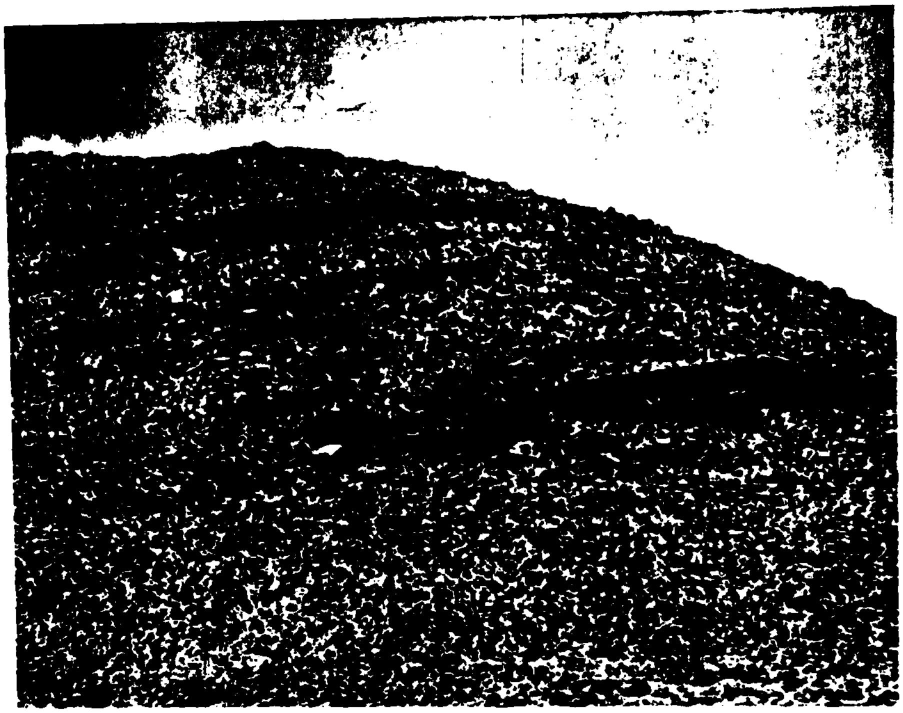
FIGURE D-3



Prospect Mountain Quartzite (Qtz) in Swasey Mountain;
Class I crushed rock aggregate source (Station 54).

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TULE VALLEY
STUDY AREA PHOTOGRAPH

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FIGURE D-4

Notch Peak Formation (Cau) in the Gray Hills, southern Tule Valley; Class I crushed rock aggregate source.

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TULE VALLEY
STUDY AREA PHOTOGRAPH

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FIGURE D-5

Laketown Dolomite (Do) in the Contusion Range;
Class I crushed rock aggregate source (Station 20).

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TULE VALLEY
STUDY AREA PHOTOGRAPH

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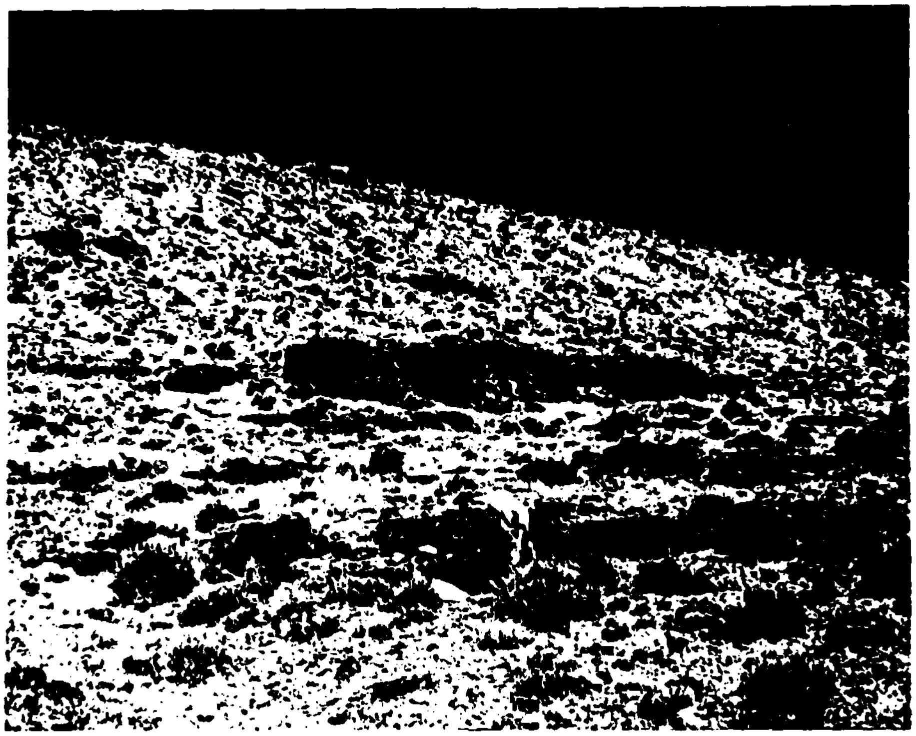
FIGURE D 6



Basalt (Vb) in northern Tule Valley; Class I crushed rock aggregate source (Station 34).

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TULE VALLEY
STUDY AREA PHOTOGRAPH

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FIGURE D 7

APPENDIX E

ERTEC WESTERN GEOLOGIC UNIT CROSS REFERENCE

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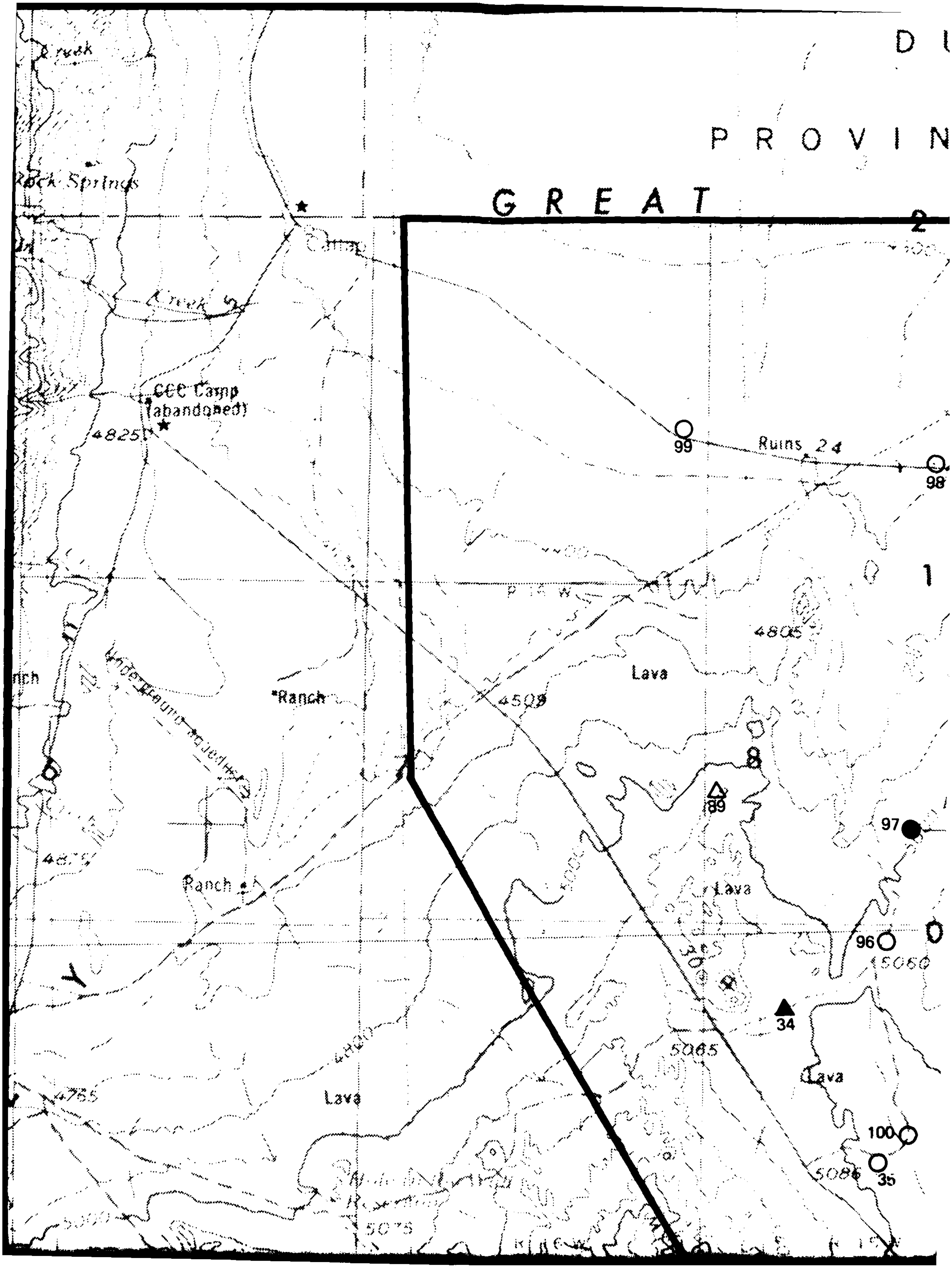
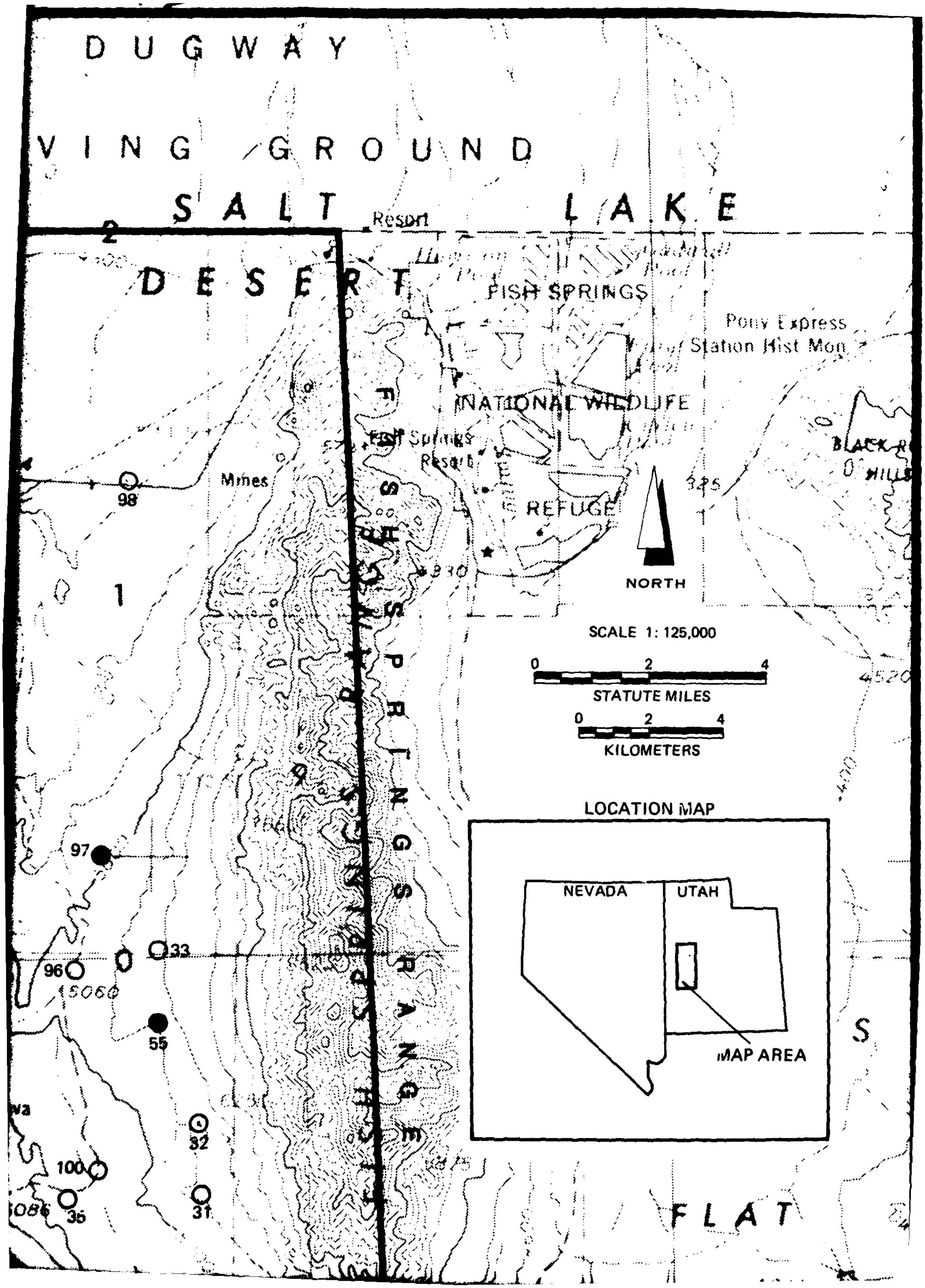
AGGREGATE RESOURCES GEOLOGIC UNIT SYMBOLS		ERTEC WESTERN GENERAL GEOLOGIC UNIT EXPLANATION
		ROCK
		Shown in regions where rock is exposed, the areally predominant (greater than 70 percent) rock type is indicated. In those areas where two rock types occur the predominant rock type is shown followed by the subordinate rock type (e.g. S_{2}, I_{4}). Rock may be subdivided into bedrock (R).
	I	IGNEOUS (UNDIFFERENTIATED): Rocks formed by solidification of a molten or partially molten mass
Gr	I_1	Intrusive: Plutonic rocks formed by solidification of molten material beneath the surface (e.g. granite, granodiorite, diorite, gabbro)
Vu	I_2	Extrusive (intermediate and acidic): Volcanic rocks of intermediate and acidic composition formed by solidification of molten material at or near the surface (e.g. rhyolite, latite, dacite, andesite)
Vb	I_3	Extrusive (basic): Volcanic rocks of basic composition generally formed by solidification of molten materials at or near the surface (e.g. basalt)
Vu	I_4	Extrusive (pyroclastic): Rocks formed by accumulation of volcanic ejecta (e.g. ash, tuff, welded tuff, agglomerate)
Su	S	SEDIMENTARY (UNDIFFERENTIATED): Rocks formed by accumulation of clastic solids, organic solids and/or chemically precipitated minerals
Su, Qtz	S_1	Arenaceous and/or Siliceous Rocks: Composed of sand size particles (e.g. sandstone, orthoquartzite) or of cryptocrystalline silica (e.g. opal, chert)
Ls, Do, Cau	S_2	Carbonate Rocks: Composed predominantly of calcium carbonate detritus or chemical precipitates (e.g. limestone, dolomite, chalk)
	S_3	Argillaceous Rocks: Composed of clay and silt-sized particles (e.g. siltstone, shale, claystone)
	S_4	Evaporite Rocks: Precipitated from solution as a result of evaporation (e.g. halite, gypsum, anhydrite, sylvite)
Su	S_5	Coarse Clastic Rocks: Composed of gravel-sized or larger clasts (e.g. conglomerate, breccia)
Mu	M	METAMORPHIC (UNDIFFERENTIATED): Rocks formed through recrystallization in the solid state of preexisting rocks by heat and pressure
Mu	M_1	Coarse grained: rocks formed by higher-grade regional metamorphism, either banded or granular (e.g. gneiss, granulite, amphibolite)
Mu	M_2	Fine grained: schistose rocks formed by lower grade regional metamorphism (e.g. schist, slate, phyllite)
Mu	M_3	Nonfoliated: rocks formed chiefly by contact metamorphism (e.g. hornfels, marble)
Qtz	M_4	Metaquartzite: rocks formed by metamorphism of highly siliceous rocks
		BASIN-FILL
	A	BASIN-FILL DEPOSITS: Fine- to coarse-grained materials deposited principally by wind, water or gravity
Aal	A_1	Younger Fluvial Deposits: Major modern stream channel and flood-plain deposits
Au,- Aal	A_2	Older Fluvial Deposits: Older incised stream channel and flood-plain deposits in elevated terraces bordering major modern drainages
Au	A_3	Eolian Deposits: Wind-blown deposits of sand occurring as either thin sheets (A_{3s}) or dunes (A_{3d})
Aol	A_4	Playa and Lacustrine Deposits: Deposits occurring in modern, active playas (A_4) or in either inactive playas or older lake beds and abandoned shorelines associated with extinct lakes (A_{4o})
Aaf	A_5	Alluvial Fan Deposits: Alluvial deposits consisting of debris flow and water-laid alluvium near mountain fronts, grading into predominantly water-laid alluvium deposited in shifting distributary channels near the basin center. Younger (A_{5y}), intermediate (A_{5i}) and older (A_{5o}) alluvial fans are differentiated by surface soil development, terrain conditions and present depositional/erosional environment
Au	A_3/A_5	Mixed non-rock units: Most areally extensive unit is listed first
Aaf	A_{5y} (A_{5i})	Parenthetic unit underlies thin veneer of overlying mapped unit

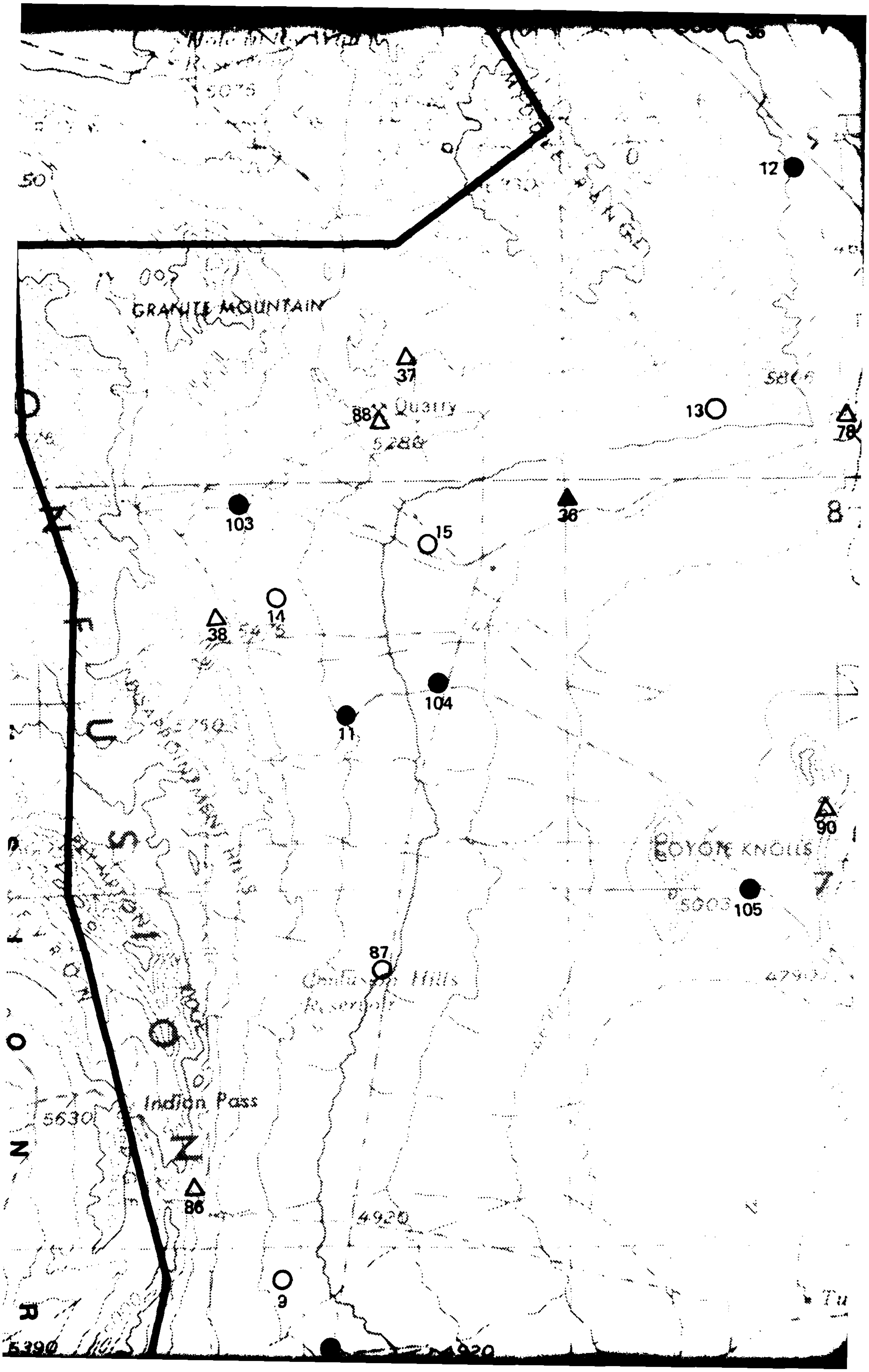
ERTEC WESTERN GEOLOGIC UNIT
CROSS REFERENCE



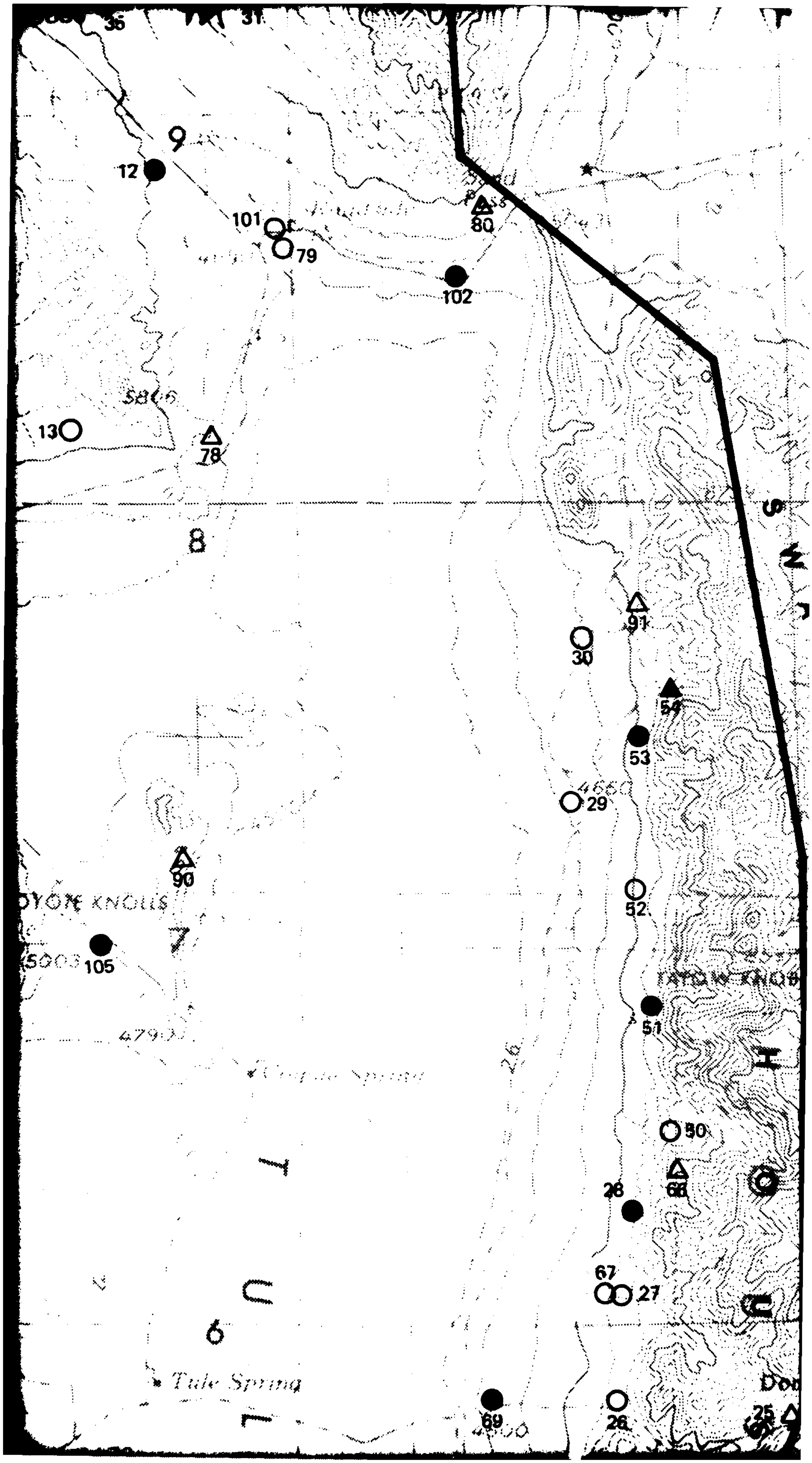
D
P R O V I N
G R E A T
2
Rock Springs
Camp
Creek
CCC Camp
(abandoned)
4825
99
Ruins 24
98
1
4805
Lava
Ranch
Ranch
4509
89
97
Ranch
Lava
96
5060
0
34
5065
Lava
4800
4755
Lava
100
35
5086
5075
5000



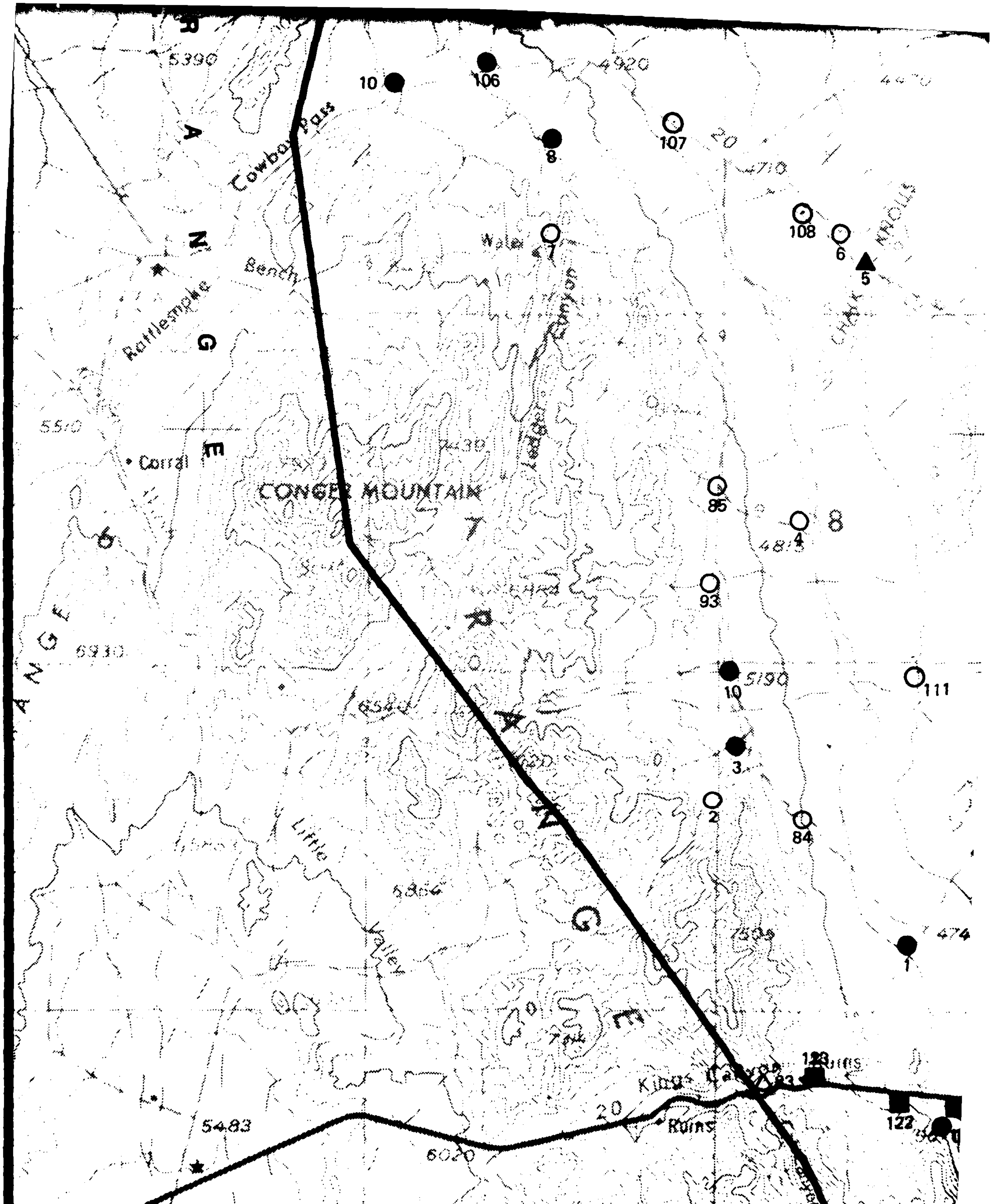
DUGWAY
VING GROUND
SALT LAKE
DESERT
Resort
FISH SPRINGS
NATIONAL WILDLIFE
REFUGE
Pony Express
Station Hist Mon
Fish Springs
Resort
Mines
FISH SPRINGS RANGE
FLAT
NORTH
SCALE 1: 125,000
0
2
4
STATUTE MILES
0
2
4
KILOMETERS
LOCATION MAP
NEVADA
UTAH
MAP AREA
1
2
98
97
96
33
55
32
100
36
31



GRANITE MOUNTAIN
37
88
Quarry
5288
12
13
78
103
36
15
14
38
104
11
90
COYOTE KNOLLS
5003
105
87
Indian Pass
5630
86
4920
9
5390

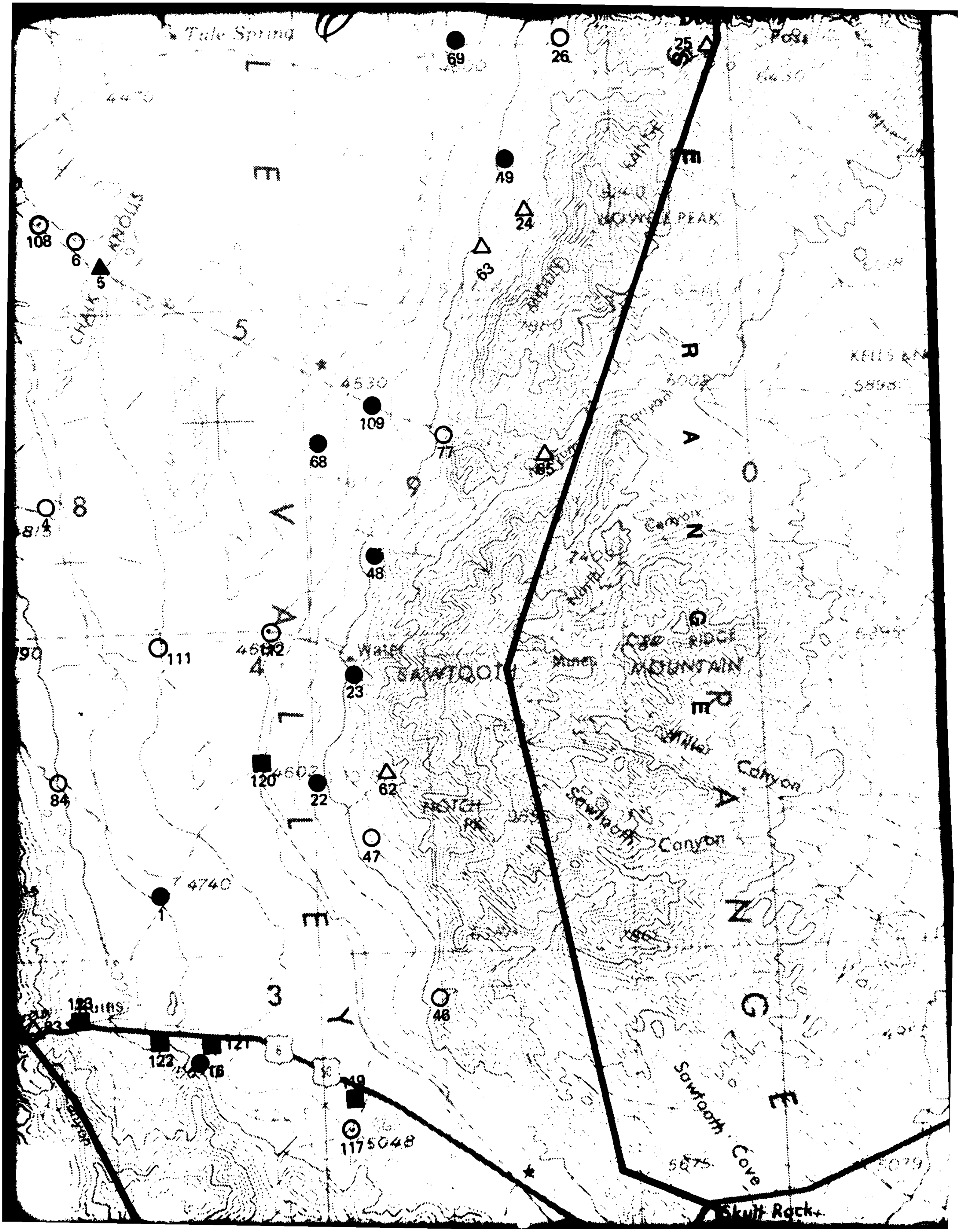


36
31
9
12
101
79
80
102
5806
13
78
8
91
30
54
53
29
90
COYOTE KNOLLS
105
7
51
TATOW KNOB
50
68
28
67
27
6
Tule Spring
69
26
25



EXPLANATION

NATIONAL FIELD STATIONS


Tule Spring
69
26
25
49
24
108
6
5
CHALK KNOLLS
HOWELL PEAK
63
4530
109
77
68
85
8
4
48
111
112
23
SAWTOOTH
MOUNTAIN
RIDGE
120
4602
22
62
84
47
NOTCH PK
Miller Canyon
Sawtooth Canyon
4740
1
46
123
122
121
16
119
117
5048
Sawtooth Cove
Skull Rock
V A L L E Y
R A N G E
R A N G E

EXPLANATION

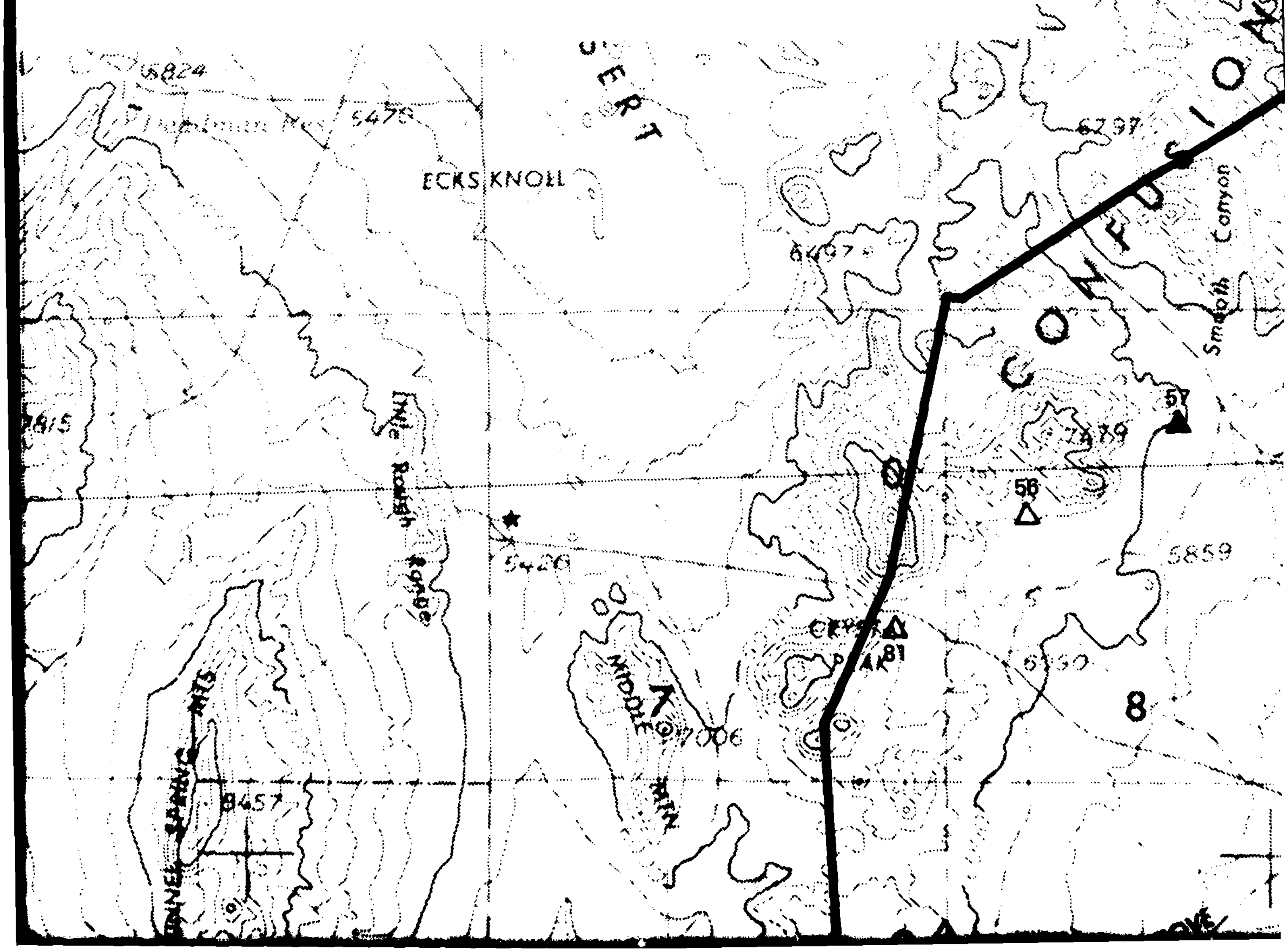
ERTEC NATIONAL FIELD STATIONS

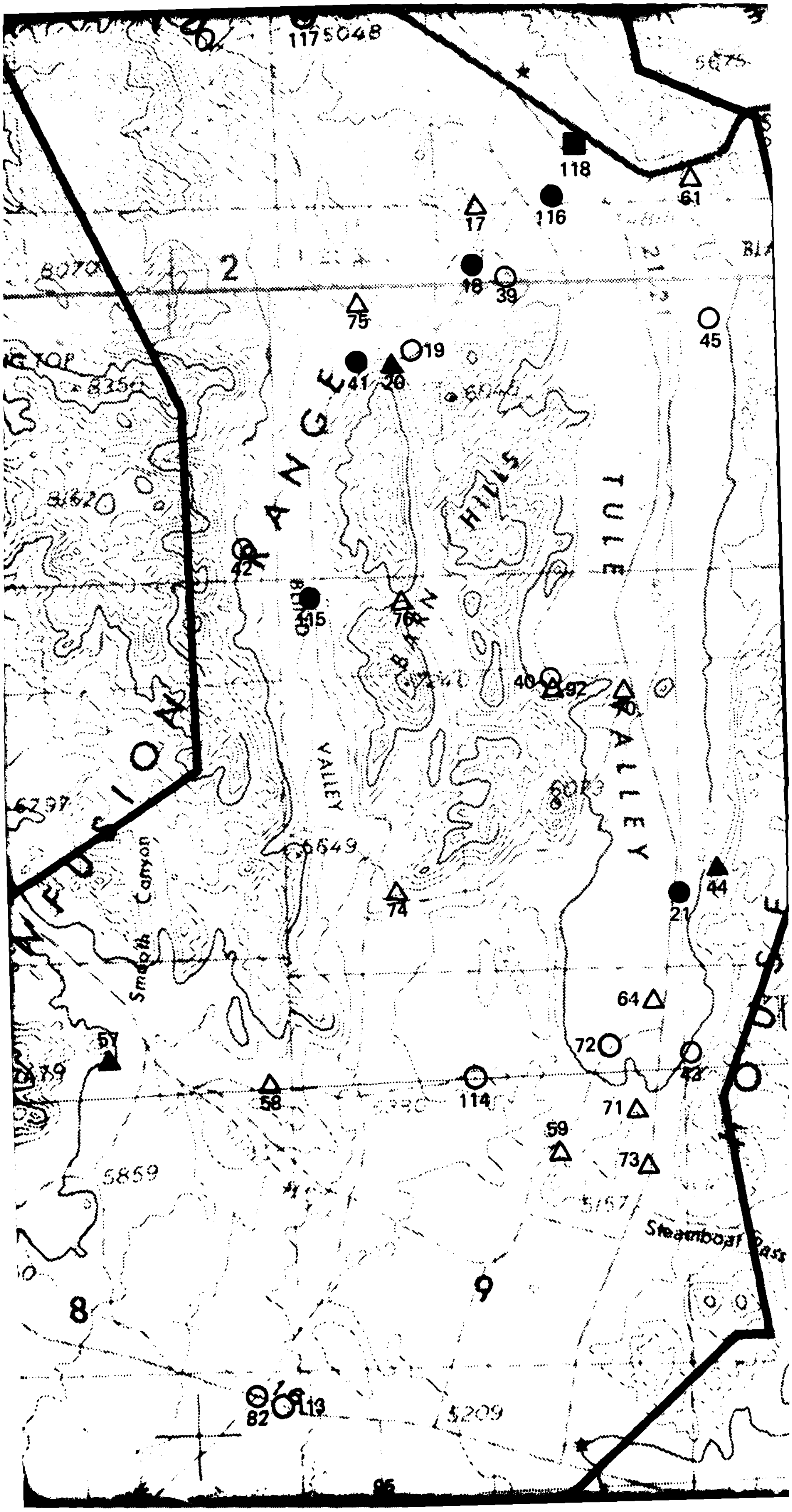
BASIN–FILL UNITS	(Potential Coarse and/or Fine Aggregates)
●	Data Stop, Sampled and Tested
○	Data Stop
ROCK UNITS	(Potential Crushed Rock Aggregates)
▲	Data Stop, Sampled and Tested
△	Data Stop

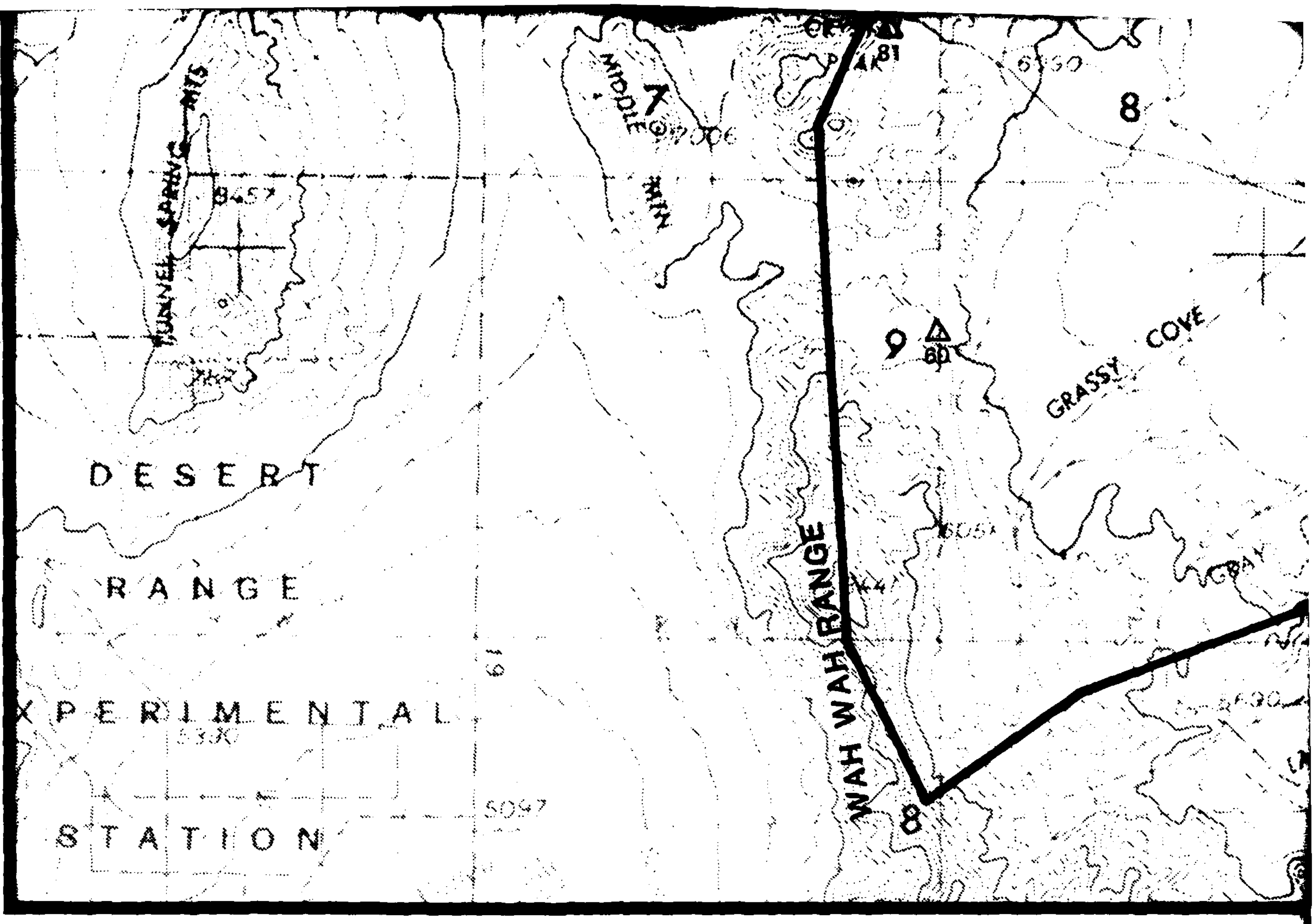
EXISTING TEST DATA SITES

■	Test Data Available

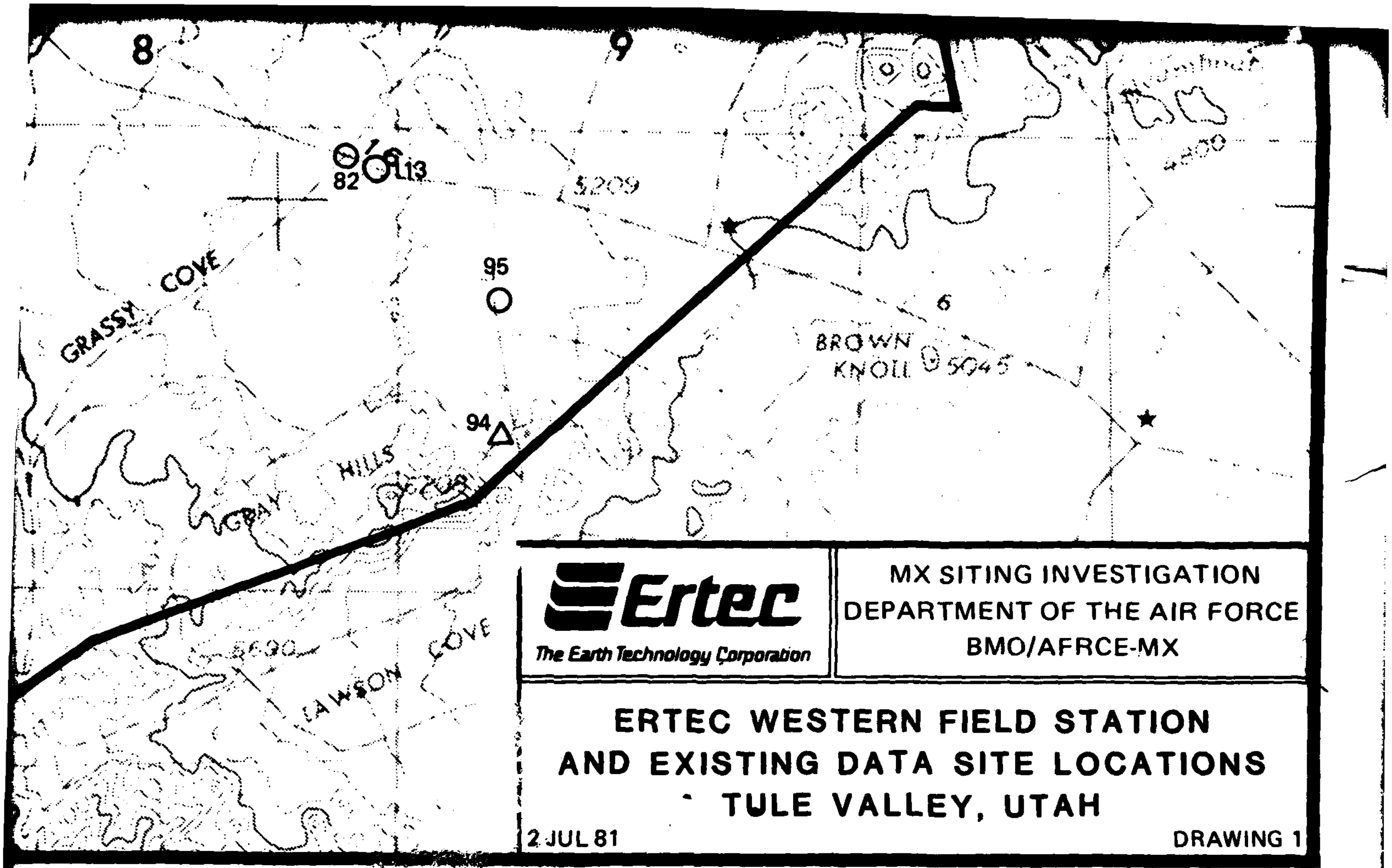
Note: See Corresponding Map Number in Appendix A for Detailed Information




117
5048
118
61
17
116
2
18
39
75
45
19
41
20
RANGE
HILLS
TULE
42
115
76
40
92
70
VALLEY
TULE VALLEY
6649
74
21
44
Smooth Canyon
64
72
43
57
58
114
71
59
73
5859
Steamboat Pass
9
8
82
113
5209



TUNNEL SPRING MTS
8457
MIDDLE MTN
7
8
9
60
81
GRASSY COVE
DESERT
RANGE
XPERIMENTAL
STATION
5330
5097
WAH WAH RANGE
8
6053
GRAY



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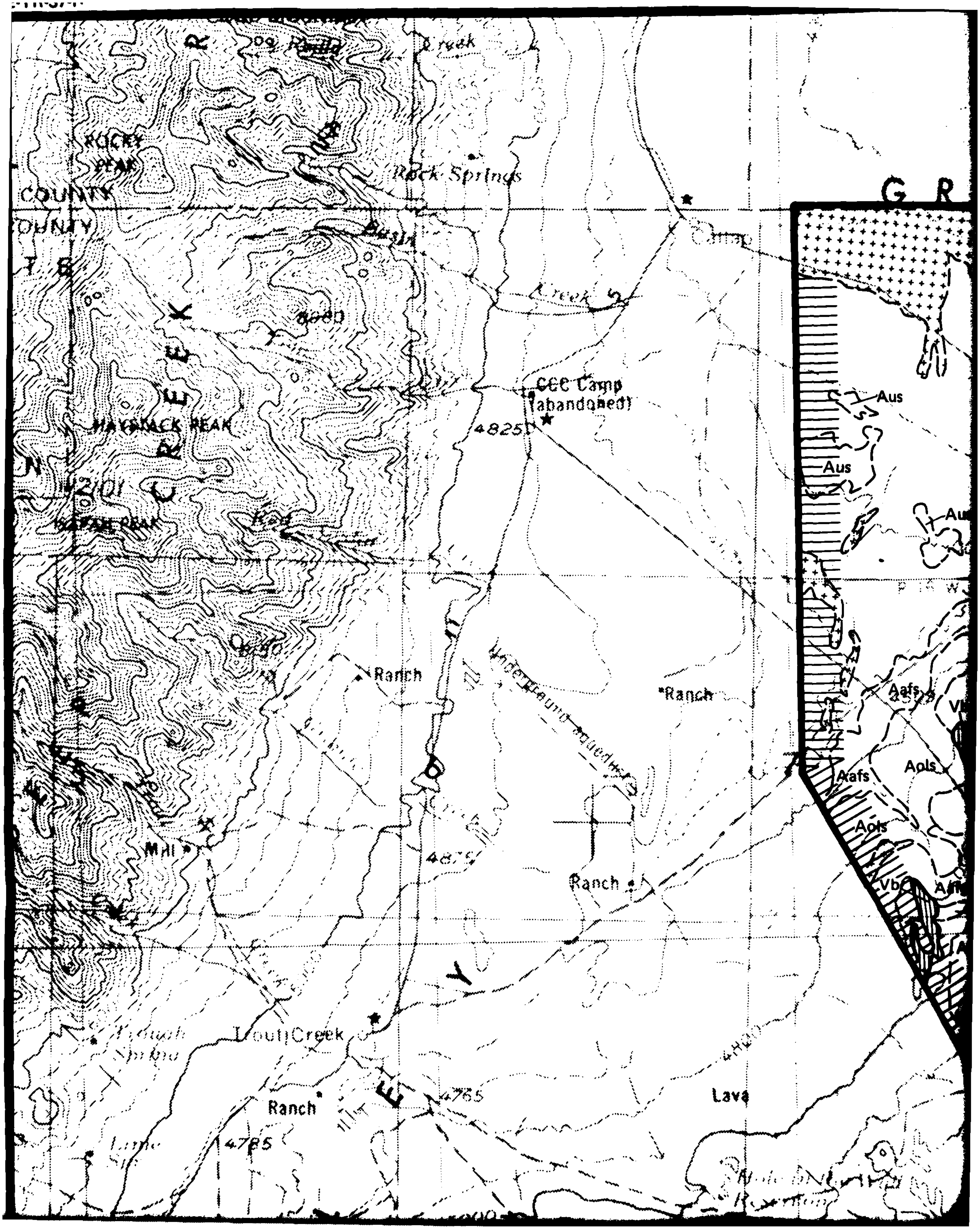
ERTEC WESTERN FIELD STATION AND EXISTING DATA SITE LOCATIONS TULE VALLEY, UTAH

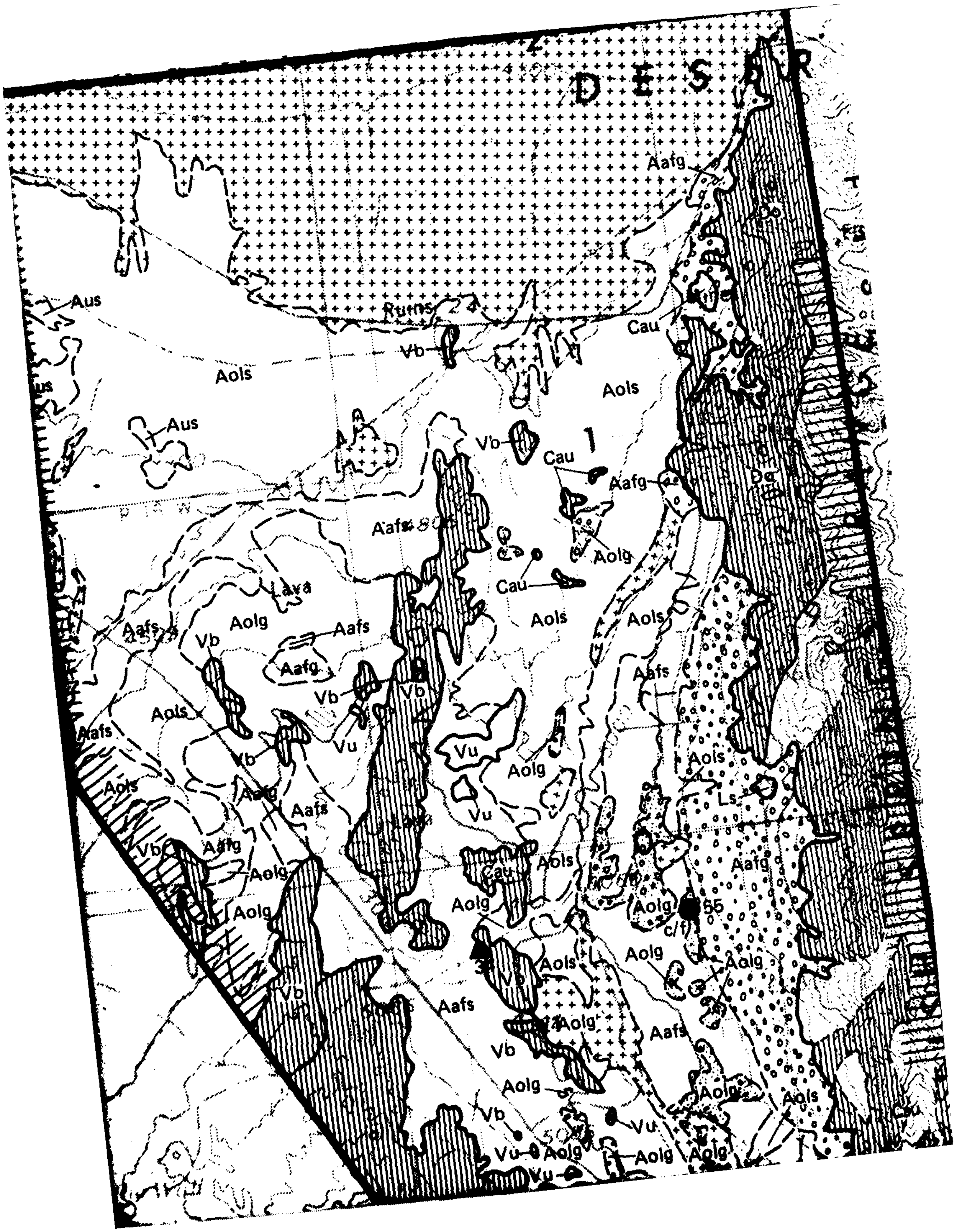
2 JUL 81

DRAWING 1

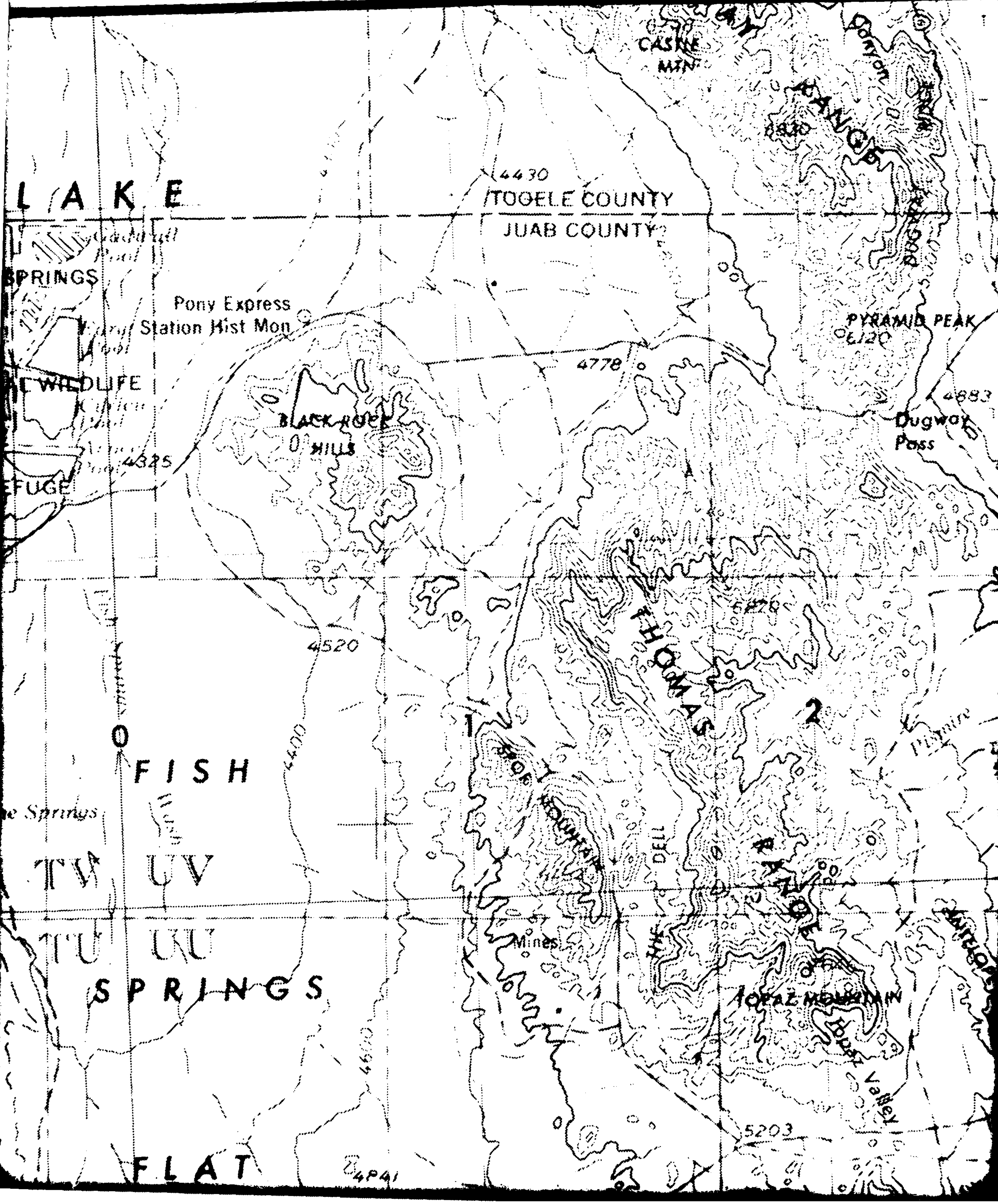
10



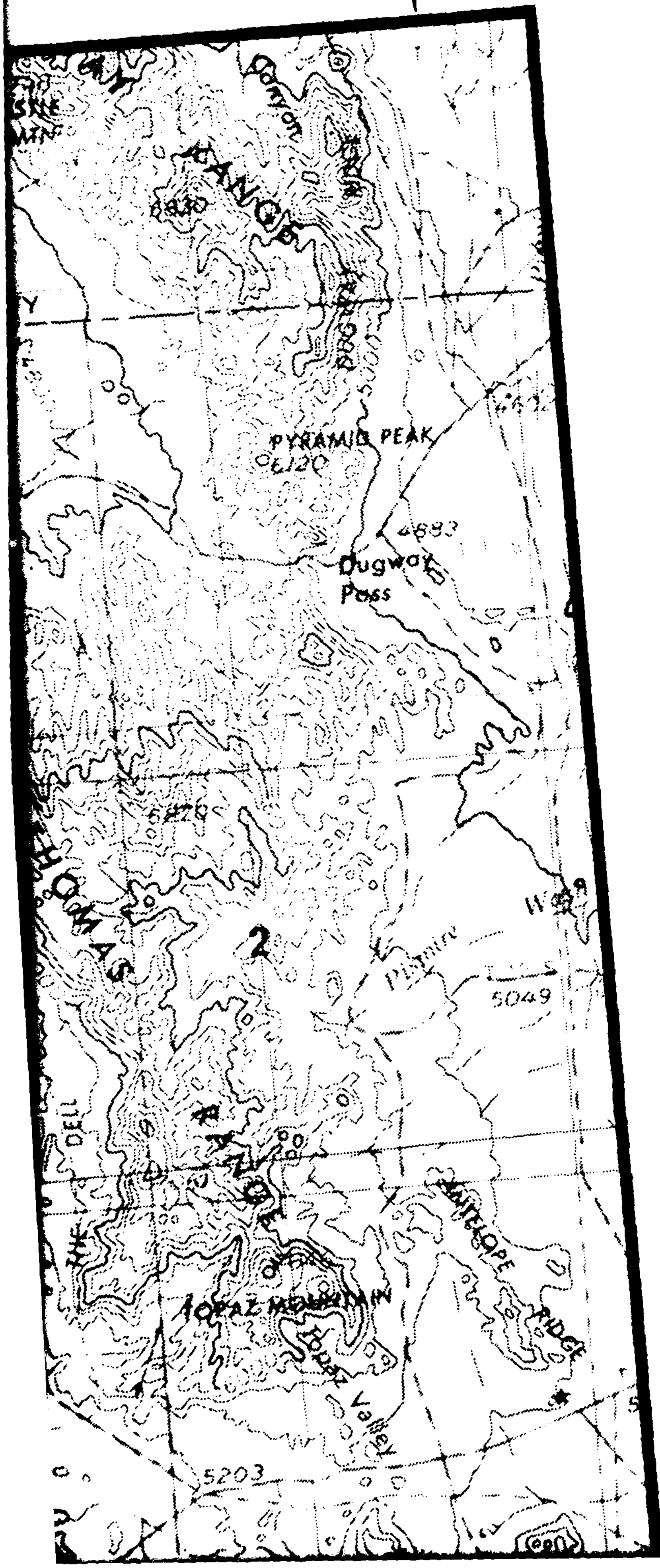
ROCKY PEAK
Rock Springs
COUNTY
COUNTY
Basin
Creek
CCC Camp
(abandoned)
4825
HAYSTACK PEAK
G R
Aus
Aus
Ranch
Ranch
Aafs
Aafs
Aols
Aols
Vb
Mill
Ranch
Trout Creek
Ranch
4765
4785
Lava



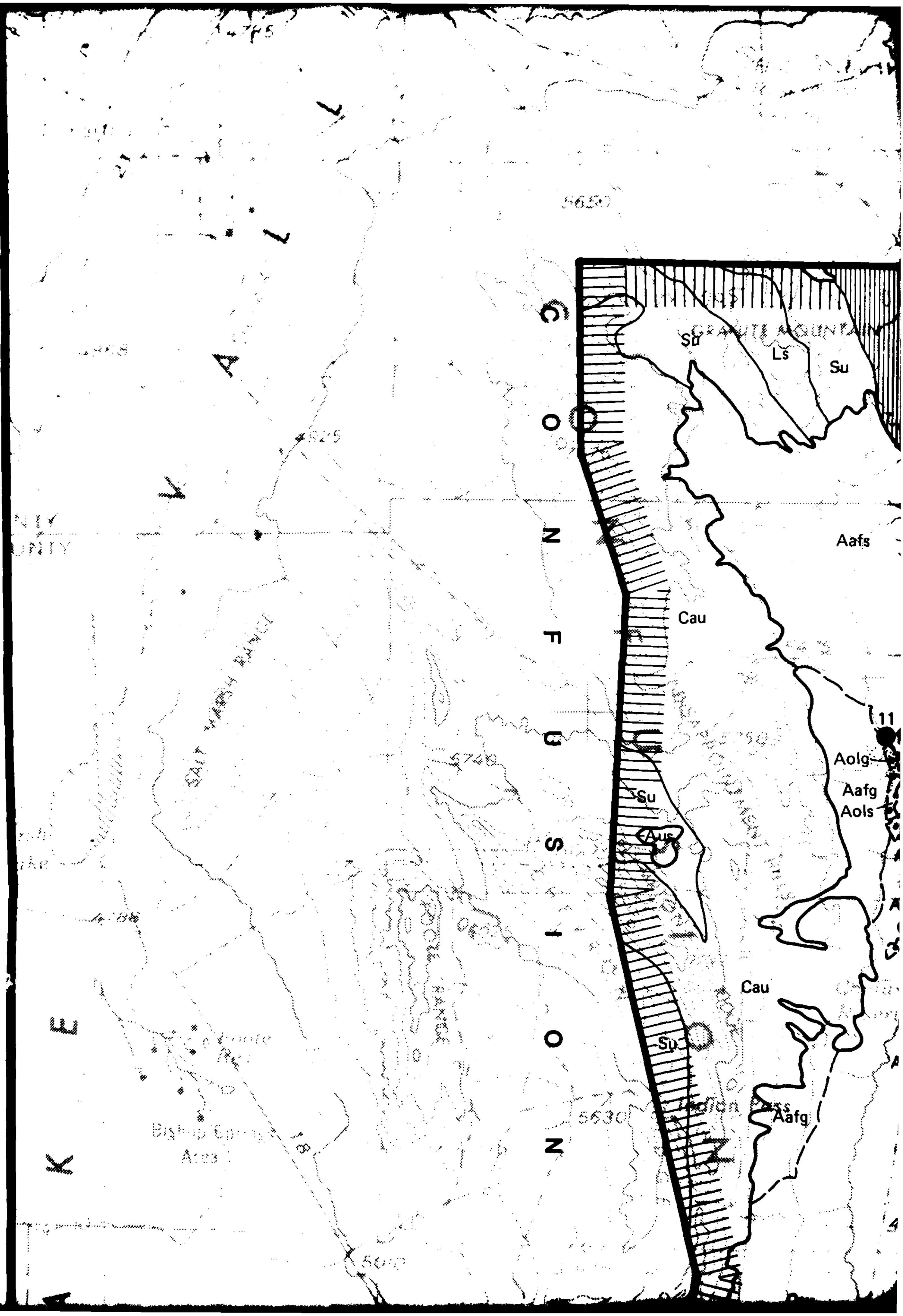
DESER
Aafg
Aus
Ruins
Vb
Aols
Cau
Aus
Vb
Cau
Aafg
Aafs
Aolg
Cau
Lava
Aolg
Aafs
Aols
Aafs
Vb
Aafg
Vb
Aafs
Aols
Vb
Vu
Vu
Aolg
Aols
Ls
Vb
Aols
Aafg
Aafs
Vu
Vb
Aafg
Aolg
Aols
Cau
Aafg
Aolg
Aolg
55
c/f
Aolg
Aols
Aolg
Vb
Aafs
Aolg
Aafs
Vb
Aolg
Aols
Vb
Vu
Vu
Aolg
Aolg
Aolg
Vu


CASTLE MTN
RANGE
6930
Canyon
4430
TOOELE COUNTY
JUAB COUNTY
LAKE
SPRINGS
Pony Express
Station Hist Mon
WILDLIFE
EFUGE
4325
BLACK ROCK
HILLS
4778
PYRAMID PEAK
6120
4883
Dugway
Pass
4520
THOMAS
RANGE
1
2
0
FISH
TV
UV
TU
UU
SPRINGS
DELL
Mines
TOPAZ MOUNTAIN
Topaz Valley
5203
FLAT
4400

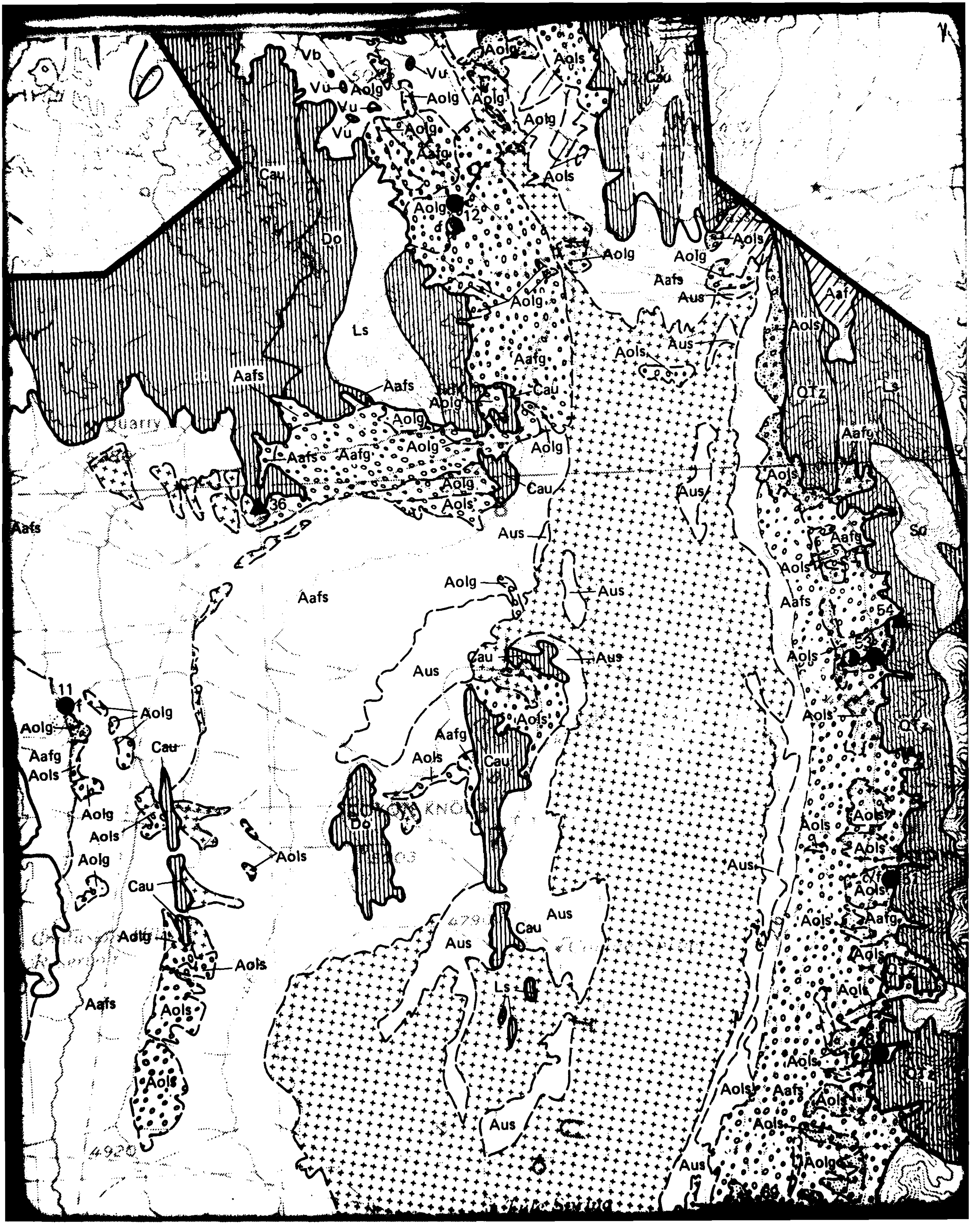
14


Canyon
RANGE
PYRAMID PEAK
6120
4683
Dugway
Pass
2
5049
ANTELOPE RIDGE
TOPAZ MOUNTAIN
Topaz Valley
5203

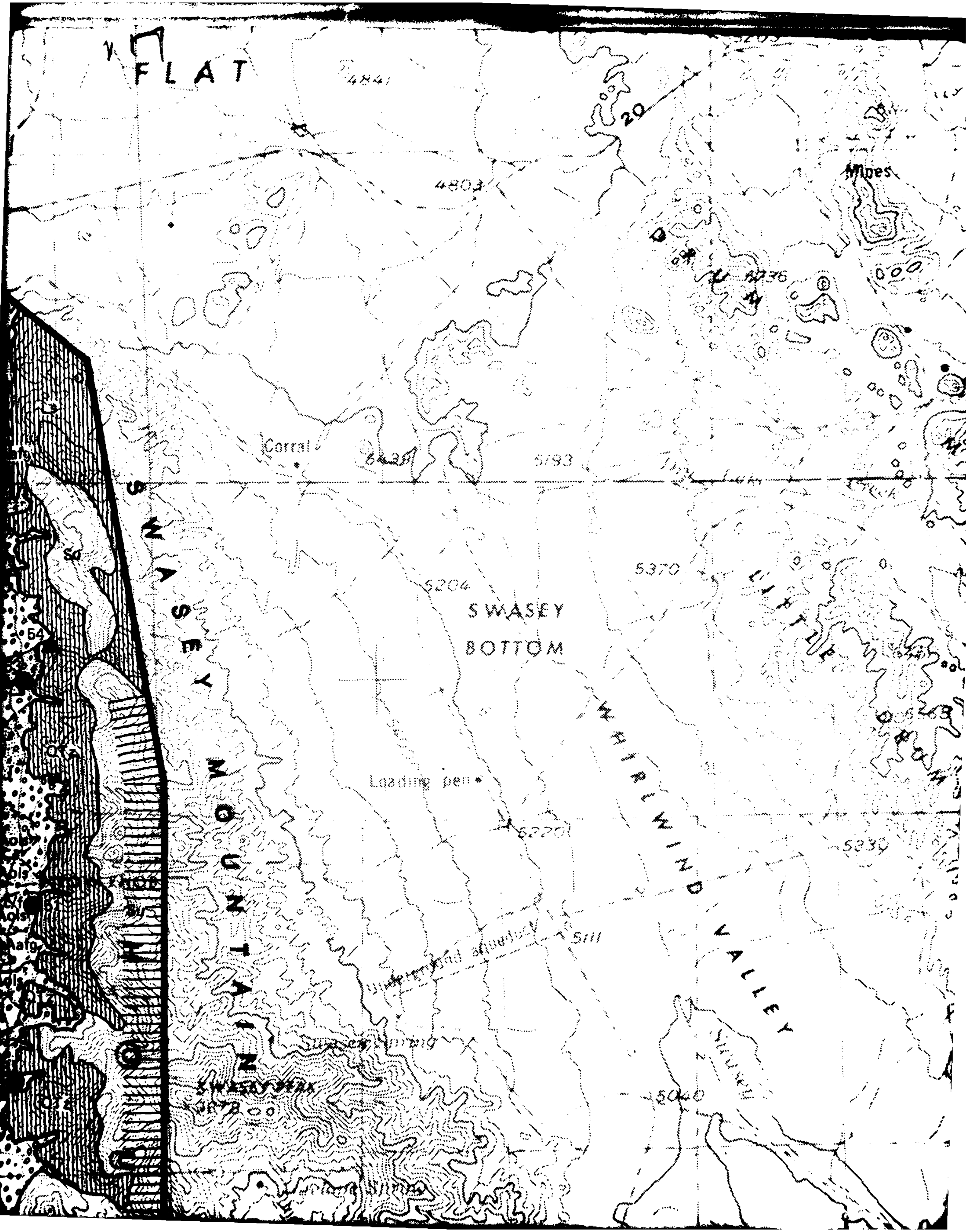
15

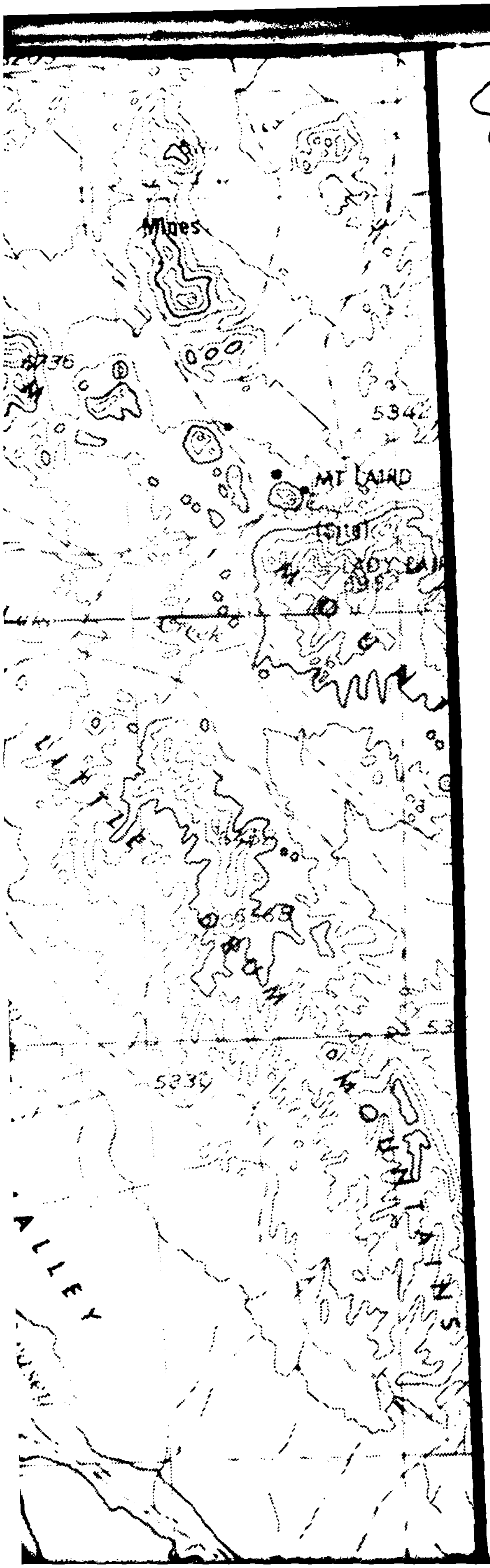


CONFUSION
GRANITE MOUNTAIN
Su
Ls
Su
Aafs
Cau
11
Aolg
Aafg
Aols
Su
Aus
Cau
Su
Aafg
Indian Pass
5650
5740
5630
Bishop Springs Area

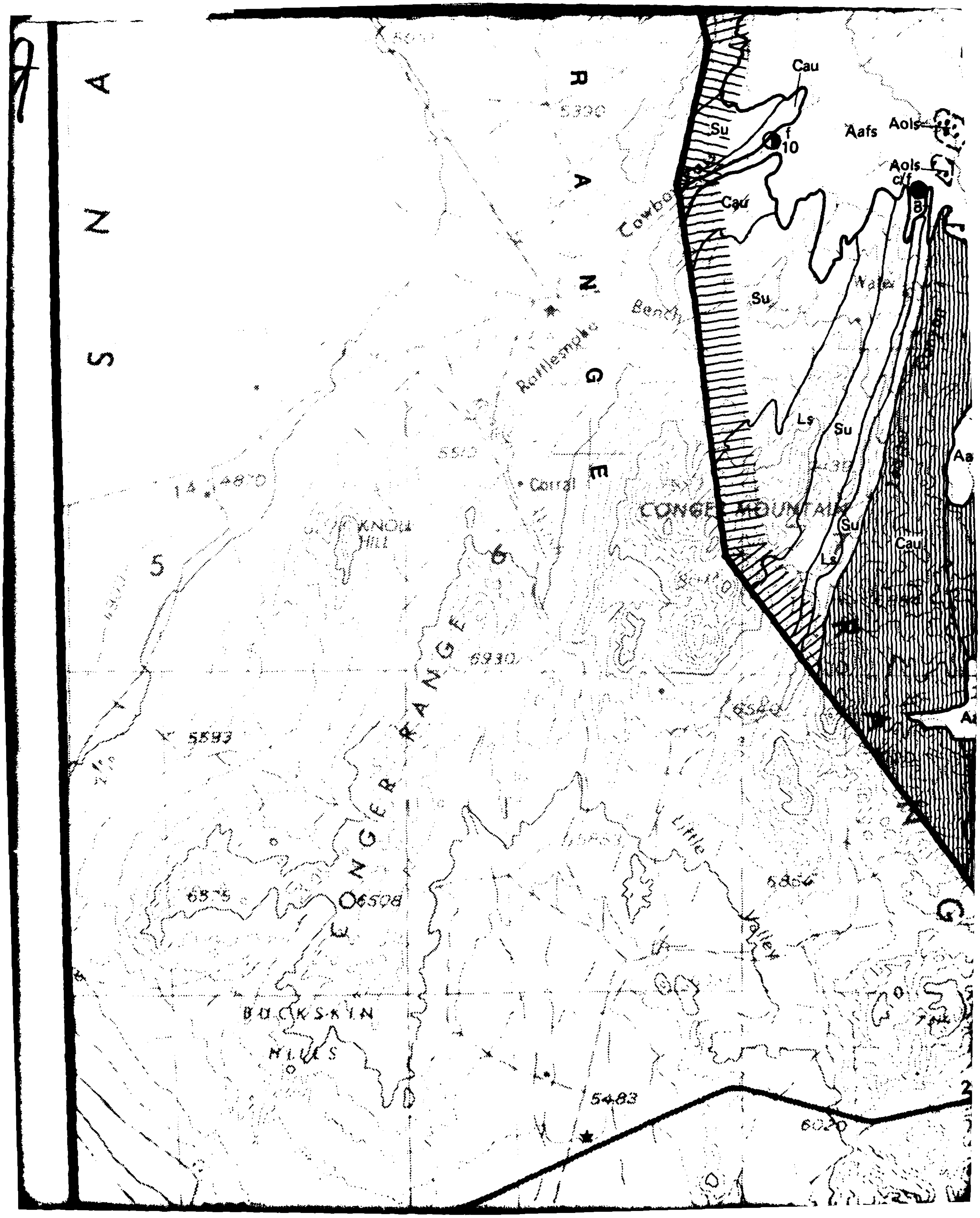


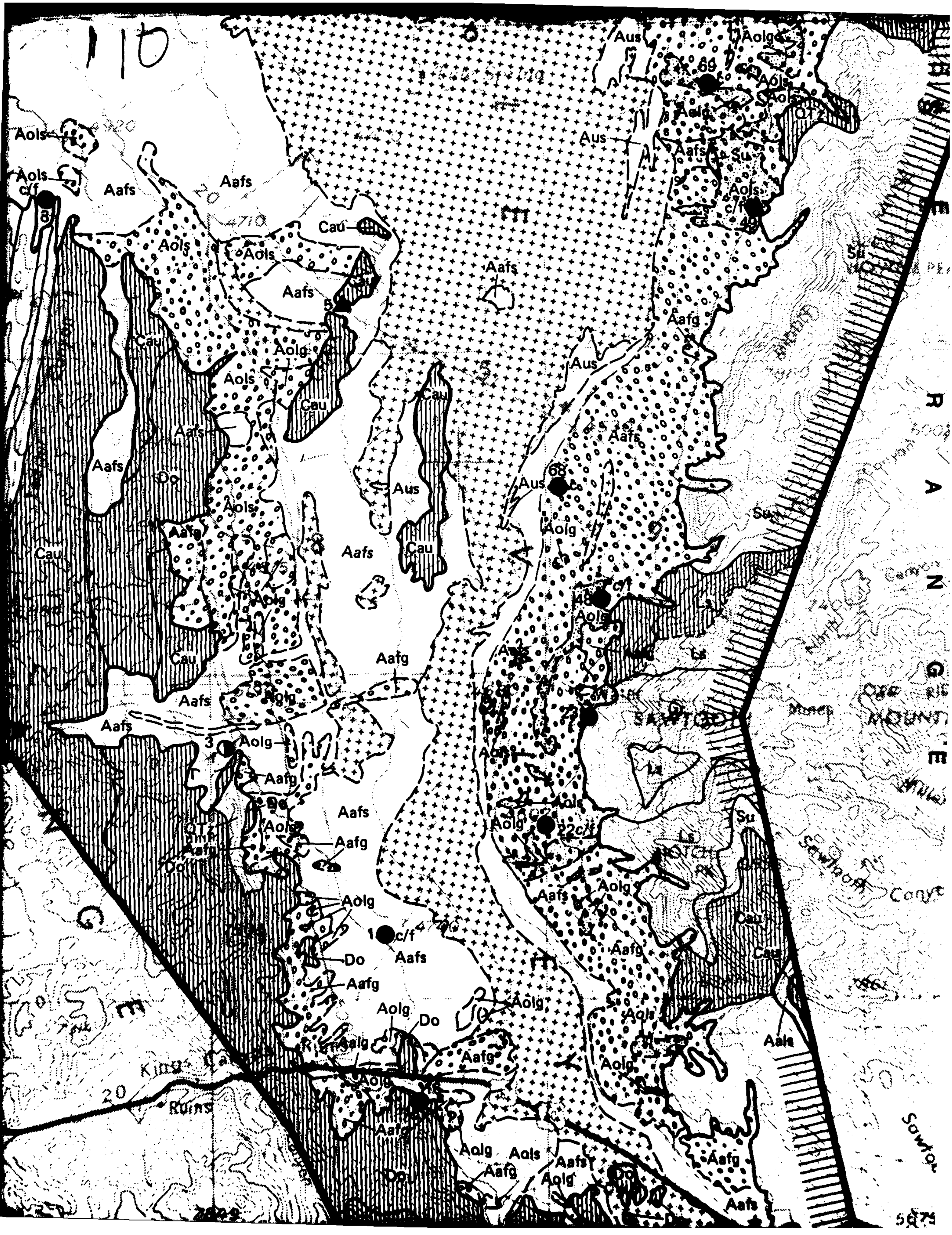
Vb
Vu
Vu
Vu
Vu
Aolg
Aolg
Aolg
Aolg
Aolg
Aols
Cau
Aafg
Cau
Aols
Aolg
12
Do
Aolg
Aols
Aolg
Aafs
Aus
Aolg
Aaf
Ls
Aols
Aols
Aus
Aafg
QTz
Ls
Aafs
Aafs
Aolg
Cau
Aolg
Quarry
Aolg
Aafg
Aafs
Aafg
Aolg
Aolg
Aols
Aus
Cau
Aols
36
Aafs
Aus
Aafg
So
Aols
Aafs
Aolg
Aus
Aafs
54
Cau
Aus
Aus
Aols
11
Aolg
Aols
Aolg
Aolg
Aafg
Aafg
Cau
Aols
Aols
Cau
Aolg
Aols
Aols
Do
Aolg
Aols
Aus
Aols
Cau
Aols
Aolg
Aafg
Aus
Cau
Aols
Aus
Aolg
Aols
Aafs
Ls
Aols
Aols
Aols
Aafs
Aols
Aols
Aus
Aols
Aolg
4920

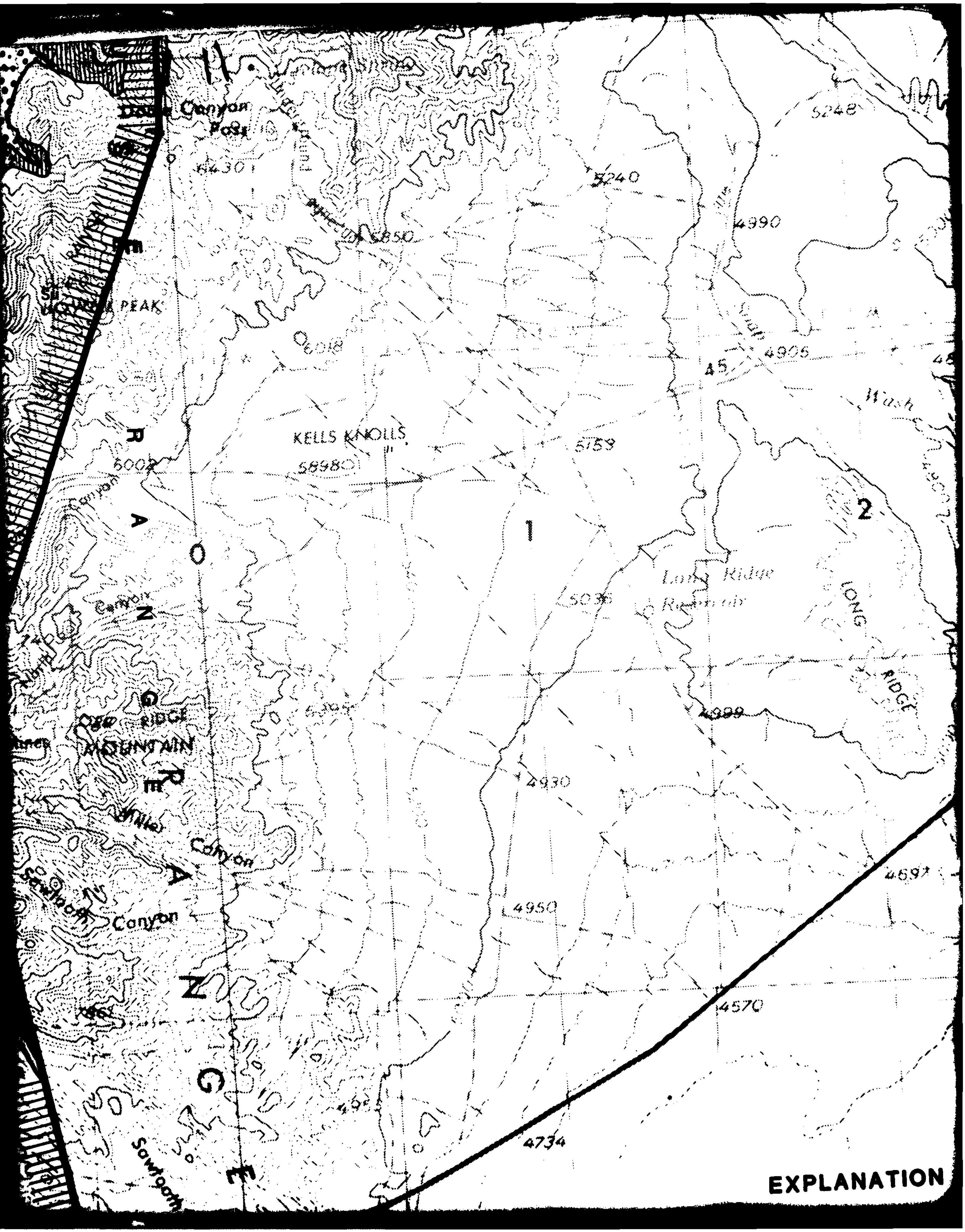

FLAT
4841
20
4803
Mines
6736
Corral
6438
5793
SWASEY MOUNTAIN
5204
SWASEY
BOTTOM
5370
WHIRLWIND VALLEY
Loading pen
5220
5330
5111
Underground boundary
5040
So
54



8

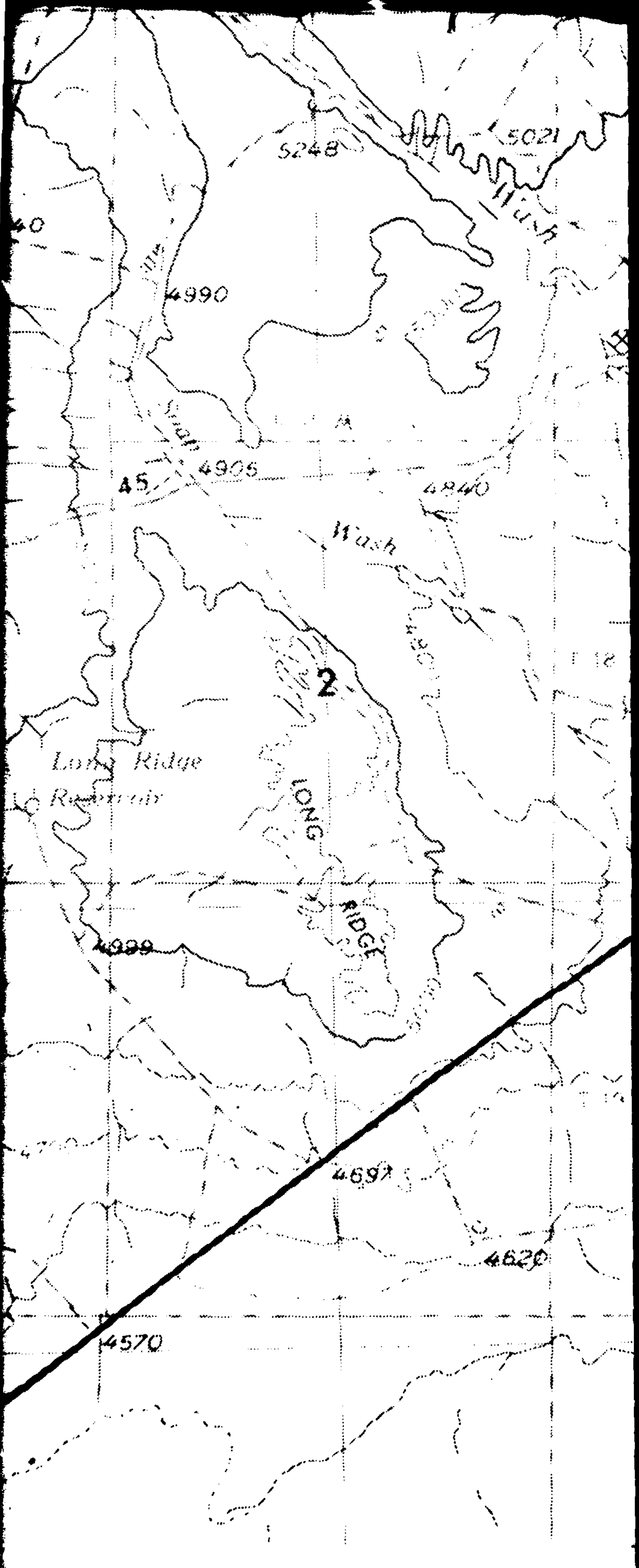

R A N G E
CONGER MOUNTAIN
CONGER RANGE
BUCKSKIN HILLS
Little Valley
Corral
Rattlesnake
Bench
Cau
Su
Aafs
Aols
Ls
10
5390
5593
6930
6875
6508
5483
6020
5806


110
Aols
c/f
Aafs
Cau
Aolg
Do
Aus
Aafg
Su
QTz
Aale
Ls
RANGE
King Ca
Ruins
Sawtooth Canyon
MOUNT

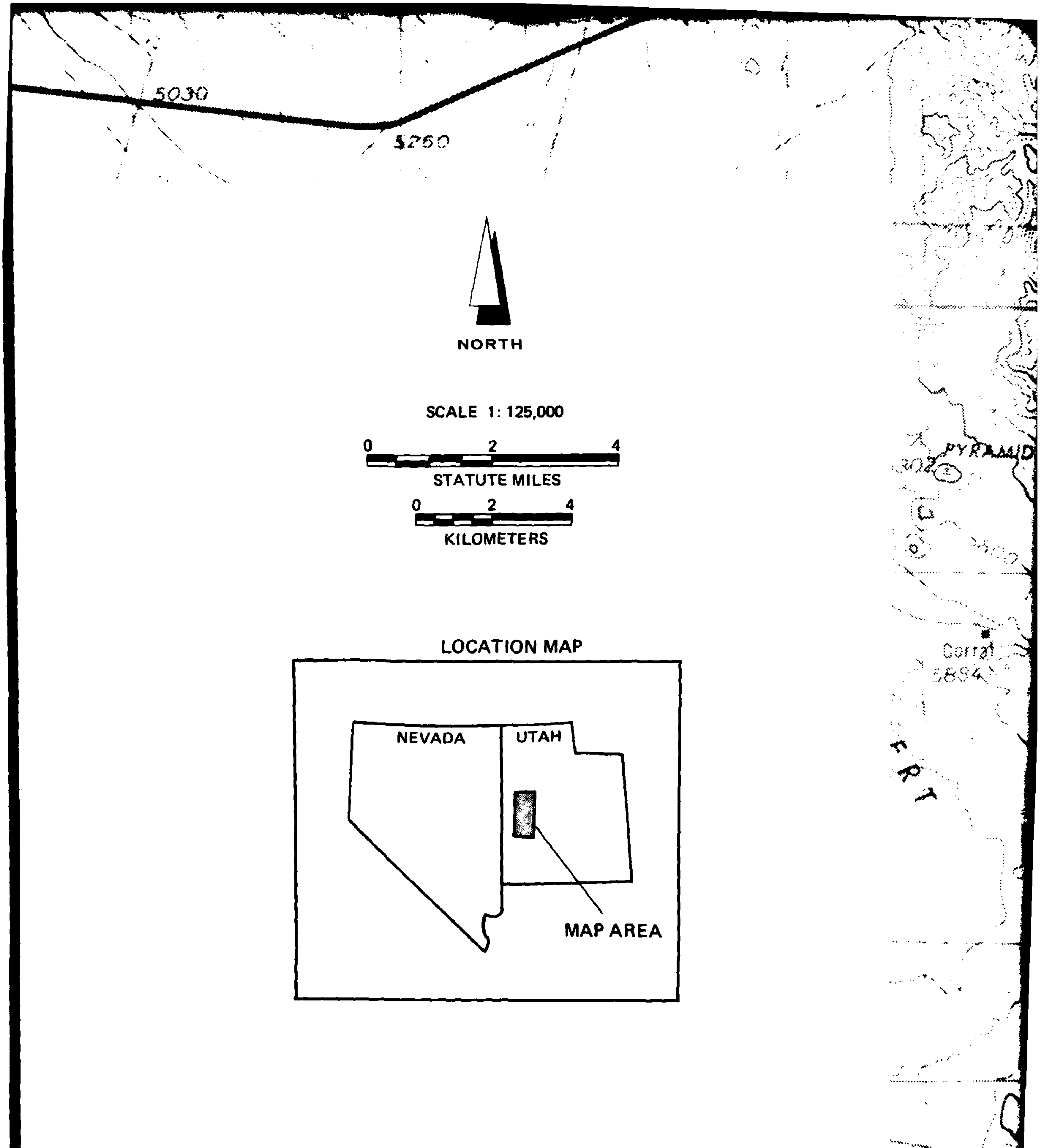


EXPLANATION

12



EXPLANATION

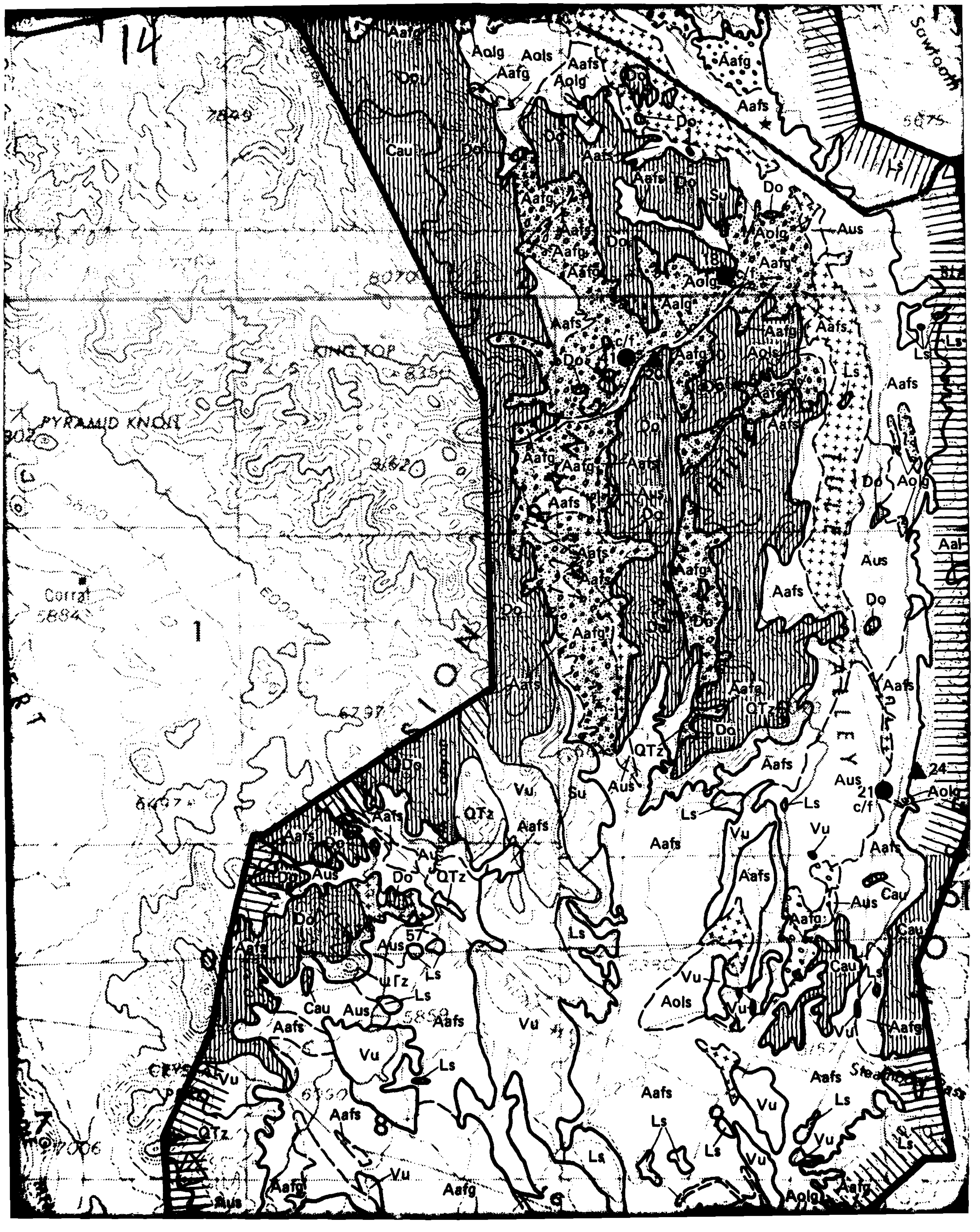


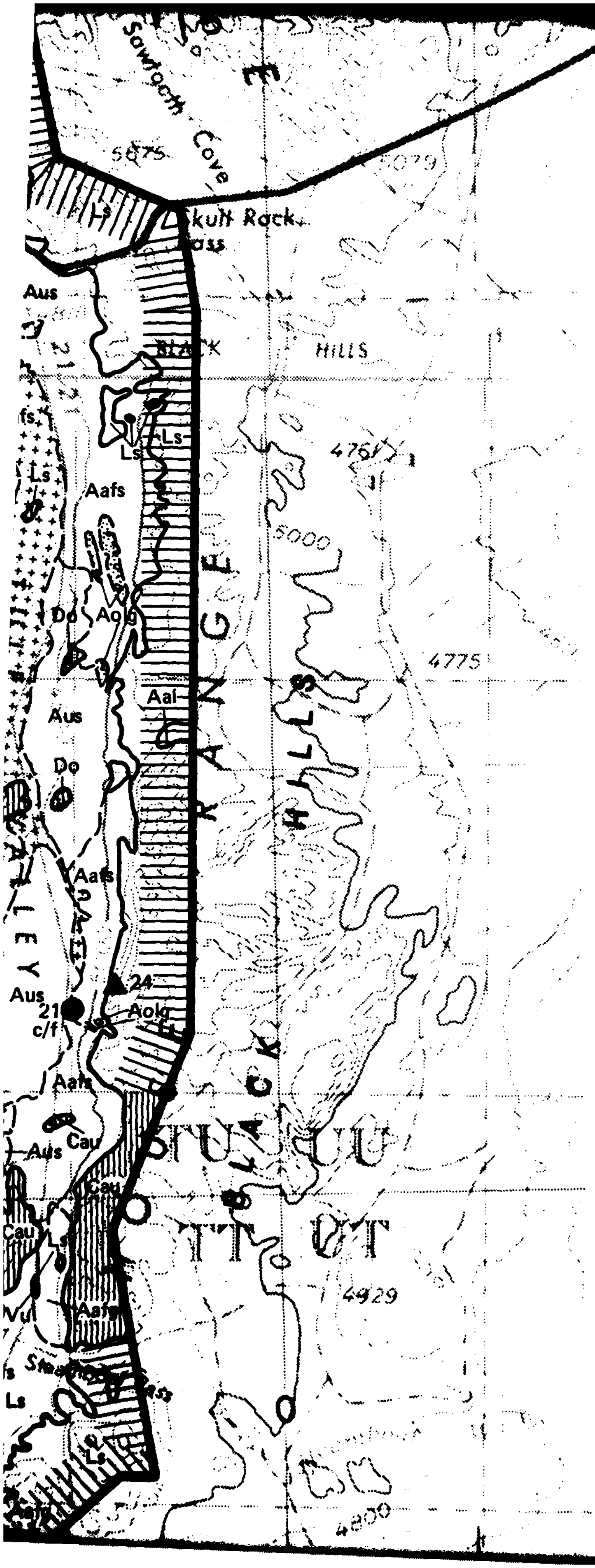
BASIN–FILL SOURCES

Class I – Potentially Suitable Coarse, Concrete Aggregate or Road - Base Material Source

Class I – Potentially Suitable Coarse and Fine (Multiple Source) Concrete Aggregate or Road-Base Material Source

ROCK SOURCES


14
Sawtooth
Aafg
Aols
Aolg
Aafs
Do
Cau
Su
Aus
Ls
Aal
c/f
KING TOP
PYRAMID KNOLL
Corral
5884
8070
8350
QTz
Vu
21
24
57
5850
6797
Steamboat Pass
1
8
7



EXPLANATION

POTENTIAL AGGREGATE SOU

BASIN–FILL UNITS *

Aal	Stream Channel and Terrace Depos
Aaf	Alluvial Fan Deposits
Aol	Older Lacustrine Deposits
Au	Alluvial Deposits Undifferentiated

Vb	Basalt
Vu	Volcanic Rocks Undifferentiated
Gr	Granitic Rock
Qtz	Quartzite
Ls	Limestone
Do	Dolomite
Cau	Carbonate Rocks Undifferentiat
Su	Sedimentary Rocks Undifferent

* Reference Appendix E for Symbol Expl

Aafg Material type (Aaf) and Grain Siz
Grain size designations are gravel

Geologic Contact, Dashed Where

Approximate Concrete Aggregat
Road-Base Materials Source Bou

Verification Study Area (Within

ERTEC WESTERN AGGREGATE R
SAMPLED AND TESTED FIELD S

BASIN–FILL AGGREGATE SAMPLE COARSE (c) AND FINE (f)	CRUSHED R SAMPLE
●	▲
◐	▲

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EXPLANATION

POTENTIAL AGGREGATE SOURCES

BASIN–FILL UNITS *

al	Stream Channel and Terrace Deposits	(A1)
af	Alluvial Fan Deposits	(A5)
ol	Older Lacustrine Deposits	(A4o)
Au	Alluvial Deposits Undifferentiated	
Vb	Basalt	(I 3)
Vu	Volcanic Rocks Undifferentiated	(I 2 and/or I 4)
Gr	Granitic Rock	(I 1)
Qtz	Quartzite	(M4 and/or S1)
Ls	Limestone	(S2)
Do	Dolomite	(S2)
Cau	Carbonate Rocks Undifferentiate	(S2)
Su	Sedimentary Rocks Undifferentiated	(S)

* Reference Appendix E for Symbol Explanation and Comparison

fg Material type (Aaf) and Grain Size Designation (g). *Grain size designations are gravel (g) and sand (s).*

— — Geologic Contact, Dashed Where Approximate

— — Approximate Concrete Aggregate and/or Road-Base Materials Source Boundary

Verification Study Area (Within Hachures)

ERTEC WESTERN AGGREGATE RESOURCES SAMPLED AND TESTED FIELD STATIONS

IEGATE SAMPLE ND FINE (f)	CRUSHED ROCK SAMPLE	CLASSIFICATION
	▲	CLASS I
		CLASS II

Class I — Potentially Suitable Coarse and Fine (Multiple Source) Concrete Aggregate or Road-Base Material Source

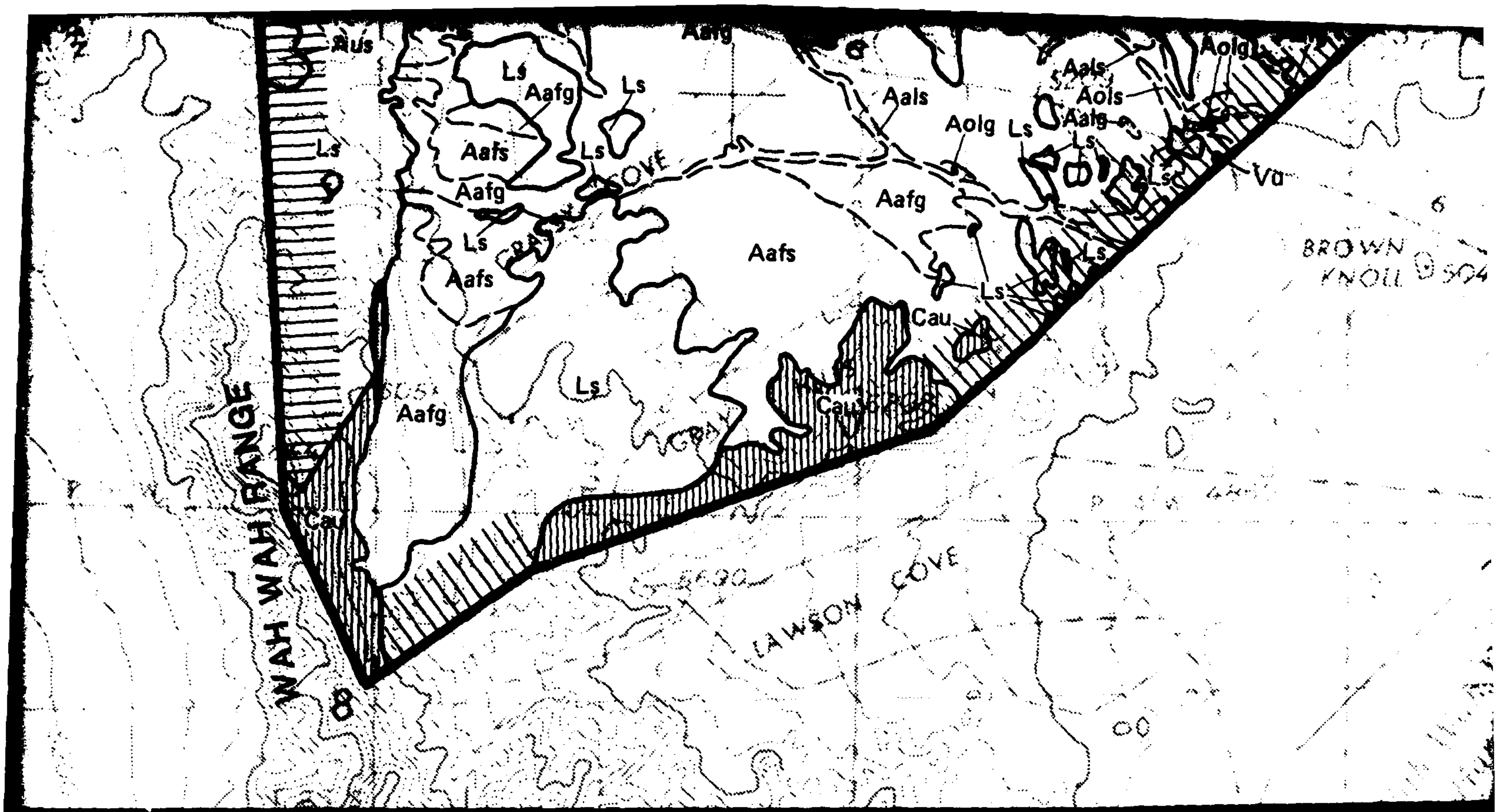
ROCK SOURCES

Class I — Potentially Suitable Crushed Rock, Concrete Aggregate or Road-Base Material Source

BASIN–FILL AND ROCK SOURCES

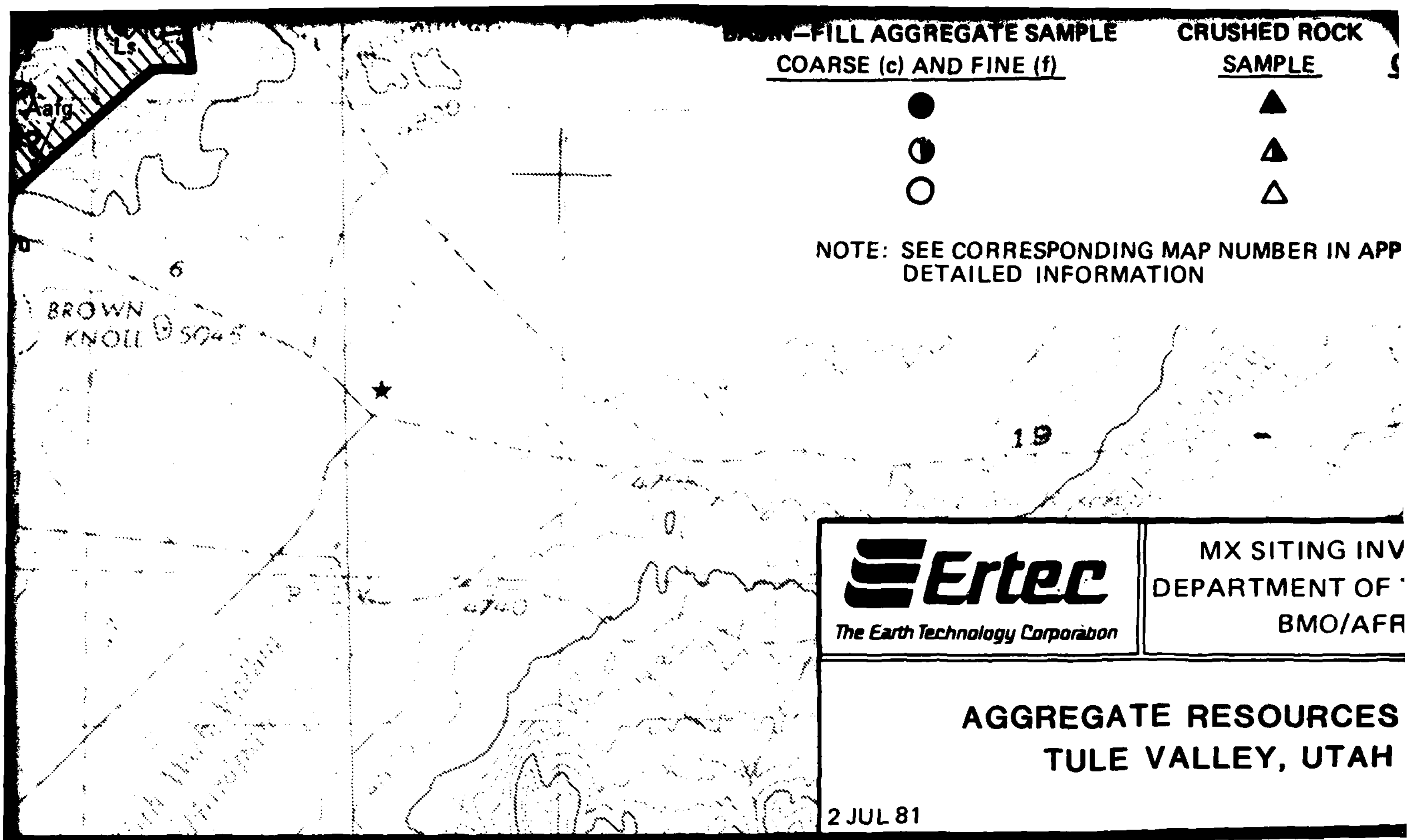
Class II — Possibly Unsuitable Coarse, Fine and/or Crushed Rock Concrete Aggregate/Potentially Suitable Road-Base Material Source

Class III — Unsuitable Coarse, Fine and/or Crushed Rock Concrete Aggregate or Road-Base Material Source


Aus
Ls
Aafg
Aafs
Aals
Aolg
Aols
Vu
Cau
BROWN KNOLL
WAH WAH RANGE
LAWSON COVE
COVE
8
9
6

1/8

1


BASIN-FILL AGGREGATE SAMPLE
COARSE (c) AND FINE (f)
CRUSHED ROCK SAMPLE
NOTE: SEE CORRESPONDING MAP NUMBER IN APP
DETAILED INFORMATION
Ls
Aafg
6
BROWN KNOLL 5945
19
4740
Ertec
The Earth Technology Corporation
MX SITING INV
DEPARTMENT OF
BMO/AFR
AGGREGATE RESOURCES
TULE VALLEY, UTAH
2 JUL 81

1 19

●	▲	CLASS I
◐	▲	CLASS II
○	△	CLASS III

NOTE: SEE CORRESPONDING MAP NUMBER IN APPENDIX A FOR DETAILED INFORMATION

Ertec
The Earth Technology Corporation

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

AGGREGATE RESOURCES MAP
TULE VALLEY, UTAH

2 JUL 81

DRAWING 2

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